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Prepared in cooperation with the U.S. Department of Energy

Field Methods, Quality-Assurance, and Data Management Plan for Water-Quality Activities and Water-Level Measurements, Idaho National Laboratory, Idaho

Open-File Report 2021-1004

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By Roy C. Bartholomay, Neil V. Maimer, Amy J. Wehnke, and Samuel L. Helmuth

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**U.S Department of the Interior
U.S. Geological Survey**

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
Length		
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
Flow rate		
gallon per minute (gal/min)	0.06309	liter per second (L/s)
Radioactivity		
picocurie per liter (pCi/L)	0.037	becquerel per liter (Bq/L)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) / 1.8$$

Datums

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Supplemental Information

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius ($\mu\text{S}/\text{cm}$ at 25 °C).

Concentrations of chemical constituents in water are given in either milligrams per liter (mg/L) or micrograms per liter ($\mu\text{g}/\text{L}$).

Activities for radioactive constituents in water are given in picocuries per liter (pCi/L).

Abbreviations

DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ESRPA	eastern Snake River Plain aquifer
INL	Idaho National Laboratory
MLMS	multi-level monitoring sampling systems
NAD 83	North American Datum of 1983
NAVD 88	North American Vertical Datum of 1988
NGVD 29	National Geodetic Vertical Datum of 1929
NRF	Naval Reactors Facility
PCFF	personal computer field form
ppm	parts per million
QAP	quality assurance plan
RESL	U.S. Department of Energy's Radiological and Environmental Sciences Laboratory
RSIL	U.S. Geological Survey's Reston Stable Isotope Laboratory
USGS	U.S. Geological Survey
VOC	volatile organic compound

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By Roy C. Bartholomay, Neil V. Maimer, Amy J. Wehnke, and Samuel L. Helmuth

Introduction

Water-quality activities and water-level measurements conducted by the U.S. Geological Survey (USGS) Idaho National Laboratory (INL) Project Office coincide with the USGS mission of appraising the quantity and quality of the Nation's water resources. The activities are conducted in cooperation with the U.S. Department of Energy's (DOE) Idaho Operations Office. Results of water-quality and hydraulic head investigations are presented in various USGS publications or in refereed scientific journals, and the data are stored in the National Water Information System (NWIS) database. The results of the studies are used by researchers, regulatory and managerial agencies, and civic groups.

In its broadest sense, "quality assurance" refers to doing the job right the first time. It includes the functions of planning for products, review and acceptance of the products, and an audit designed to evaluate the system that produces the products. Quality control and quality assurance differ in that quality control ensures that things are done correctly given the "state-of-the-art" technology, and quality assurance ensures that quality control is maintained within specified limits.

Purposes of and Responsibility for Maintaining the Quality-Assurance Plan

The purposes of the Quality-Assurance Plan (QAP) for water-quality and water-level activities performed by the USGS INL Project Office are to maintain the quality of technical products and to provide formal standardization, documentation, and review of the activities that lead to these products. The principles of this plan are as follows:

1. Water-quality and water-level programs will be planned in a technically sound manner, and activities will be monitored for compliance with stated objectives and approaches. The objectives and approaches are defined in an annual project task plan.
2. Field, laboratory, and office activities will be performed in a conscientious and professional manner in accordance with specified USGS Water Mission Area practices and procedures by qualified and experienced employees who are well trained and supervised. If USGS practices and procedures are unspecified or inadequate, the procedures used and the assessment of data quality are documented.

3. All water-quality and water-level activities will be reviewed for completeness, reliability, credibility, and conformance with specified standards and guidelines.
4. A record of actions will be kept to document the activities and the assigned responsibilities.
5. Remedial action will be taken to correct activities that are deficient.

The Chief of the USGS INL Project Office has overall responsibility for maintaining this QAP. However, the principal investigator for geochemistry and the lead personnel for the water-quality and water-level monitoring networks are directly responsible for the day-to-day maintenance of the QAP. The QAP will be formally revised and reprinted as necessary; changes that take place in the interim will be communicated by memoranda to project-office personnel on an as-needed basis, and copies of those memoranda will be stored in the USGS INL Project Office quality-assurance file and on the INL Project Office server.

Scope

The QAP for the water-quality activities and water-level measurements of the USGS INL Project Office defines procedures and tasks performed by project-office personnel that ensure the reliability of water-quality and water-level measurement data. Most of the principles of the plan have been in effect during past and current operations, but the QAP provides a method for formalizing and communicating the plan to all employees of the project office and to users of the hydrologic data and interpretive reports. The QAP was implemented in 1989 and revised in 1992, 1996 (Mann, 1996), 2003 (Bartholomay and others, 2003), 2008 (Knobel and others, 2008), and 2014 (Bartholomay and others, 2014). This version of the QAP incorporates the revisions made to the water-quality and water-level monitoring programs since 2014 and adds the processes and procedures that the INL Project Office uses to manage their water quality and water level data. A comprehensive list of references containing procedures used in data collection is given in the “References” section at the end of this report. Tasks not described by the references owing to field conditions are detailed in the following sections or in the Idaho Water Science Center Quality-Assurance Plan for Water-Quality Activities (Christopher Mebane and Rhonda J. Weakland, U.S. Geological Survey, written commun., 2016), the Quality Assurance Plan for Groundwater Activities of the USGS Idaho Water Science Center (Annette M. Campbell and James R. Bartolino, U.S. Geological Survey, written commun., June 2018), or the Idaho Water Science Center Data Management Plan (Annette M. Campbell, U.S. Geological Survey, written commun., January 2015).

Information on water-quality sampling schedules, water-level measurement schedules, data-quality objectives, water-quality field equipment, and field audits are included in appendices 1–8.

Description of Water-Quality Monitoring Networks

The USGS has maintained a water-quality monitoring program at the INL since 1949 to define:

1. The quality and availability of water for human consumption,
2. The usability of the water for supporting construction of facilities and for industrial purposes such as cooling systems and diluting concentrated waste streams,
3. The sources of recharge to the eastern Snake River Plain aquifer (ESRPA),

4. The processes controlling the origin and distribution of contaminants and naturally occurring constituents in the ESRPA,
5. The location and movement of contaminants in the ESRPA that were contained in wastewater discharged at the INL, either to the ESRPA or to the overlying perched groundwater zones, and
6. An early-detection network for contaminants moving past the INL boundaries.

Disposal of contaminants at the INL has taken place through deep disposal wells, shallow infiltration ponds, and disposal ditches.

A large network of about 300 wells has been sampled in the past, and the current routine sampling network consists of 126 wells and 5 surface-water sites (app. 1). Additional monitoring sites will be selected if needed to better document the distribution and migration of contaminants. Most of the 126 wells are open-borehole wells with a screened interval that is open to the aquifer for the entire well depth below the water table. This type of construction is adequate for identifying the time of arrival of contaminant plumes and for delineating the horizontal extent of contaminants; however, it is not conducive to identifying the vertical distribution of contaminants.

In order to better identify the vertical distribution of contaminants in the aquifer, multilevel water-quality sampling, along with pressure and temperature profiling networks, was initiated in 2005. Westbay™, packer-based, vertical multi-level monitoring sampling systems (MLMS) were installed in Middle 2050A and Middle 2051. Each well was configured so that water samples could be collected at 5 discrete depths (at both wells) and pressure and temperature measurements could be made at 15 and 13 discrete depths, respectively. In 2006, wells USGS 132 and USGS 134 were configured so that water samples could be collected at 6 and 5 discrete depths, respectively, and pressure and temperature measurements could be made at 23 and 20 discrete depths, respectively. In 2007, wells USGS 103 and USGS 133 were configured so that water samples could be collected at 7 and 4 discrete depths, respectively, and pressure and temperature measurements could be made at 23 and 13 discrete depths, respectively. In 2009, wells USGS 105 and USGS 135 were configured so that water samples could be collected at 5 and 4 discrete depths, respectively, and pressure and temperature measurements could be made at 18 and 14 discrete depths, respectively. In 2010, USGS 108 was configured so that water samples could be collected at 5 discrete depths and pressure and temperature measurements could be made at 16 discrete depths. In 2012, USGS 131A and 137A were configured so that water samples could be collected at four and four discrete depths, respectively, and pressure and temperature measurements could be made at 18 and 14 discrete depths, respectively. In 2019, USGS 149 was configured so that water samples could be collected at 4 discrete depths and pressure and temperature measurements could be made at 12 discrete depths. As with open-borehole construction, the packer-based construction allows for identifying the time of arrival of contaminant plumes and for delineating the horizontal extent of contaminants. Additionally, this type of construction provides the capability for identifying the vertical distribution of contaminants, pressure, and temperature.

The wells and streams in the INL routine network and in the MLMS network are sampled annually as indicated in appendix 1. Starting in 2020, water sample monitoring no longer occurred at USGS 134 and 135; however, pressure and temperature measurements were still collected. The Radioactive Waste Management Complex Production Well is sampled for volatile organic compounds (VOCs) on a monthly basis. In addition to the routine sampling indicated in

appendix 1, some wells may be sampled periodically for other constituents, including iodine-129, trace metals, VOCs, dissolved gases, isotopes, and compounds used for age dating.

In addition to the 131 groundwater and surface-water sites currently sampled annually for the routine-monitoring network and the 10 sites sampled for vertical definition of contaminants in the aquifer, the USGS INL Project Office staff collects water samples from 14 wells near the Naval Reactors Facility (NRF) on a semi-annual basis (app. 1). The purpose of this data-collection program is to provide the DOE's Pittsburgh Naval Reactors Office, Idaho Branch Office, with chemical and radiochemical data to evaluate the effect of NRF activities on the water quality of the ESRPA.

Description of Water-Level Monitoring Networks

The USGS has maintained a water-level monitoring program at the INL since 1949 to systematically measure water levels to provide long-term information on the ESRPA for groundwater recharge, discharge, movement, and storage. The USGS INL Project Office currently (2020) monitors 193 open boreholes (29 perched and 164 aquifer) (app. 2) and 12 MLMS that includes 190 pressure ports.

Collection of water-level data are obtained manually by use of electronic (e)-tapes and continuous data loggers. Water levels are collected monthly, quarterly, tri-annually, semi-annually or annually depending on historical data, research needs and changes in the hydrograph. Within the USGS water level monitoring network, there currently are nine continuous data loggers, two of which are equipped to transmit real-time continuous data.

USGS began installing MLMS in 2005 to provide monitoring of the vertical distribution of pressure gradients in the aquifer. Additionally, six wells (USGS 30, 139, 142, 145, HWY 1, and NRF-15) have been completed with piezometer nests at different levels of the aquifer to better define vertical distribution. The 12 MLMS were equipped with multiple measurement ports (8–23) to help improve the USGS INL groundwater modeling studies. Pressure profiles are collected either quarterly or annually depending on the location of the well and the need for information.

Field Methods for Water Quality Activities

Sample containers, sample preservation methods, field equipment, and well-head decontamination and sample-collection procedures are crucial components in assuring that data-quality objectives are achieved at the field level. Equally important are the analytical methods and the quality-control and quality-assurance activities exercised by the laboratories that analyze the samples.

Sample Containers and Preservation Methods

Sample containers and preservation methods differ depending on the chemistry of the constituents being analyzed. Samples analyzed by the USGS National Water Quality Laboratory (NWQL) are containerized and preserved in accordance with laboratory requirements that are summarized by the USGS (variously dated, chapter A5). Containers and chemical preservatives are supplied by the NWQL, where they undergo rigorous quality control to ensure that they are free of contamination (Pritt, 1989, p. 75). Samples analyzed by the U.S. Department of Energy's Radiological and Environmental Sciences Laboratory (RESL) are containerized and preserved in accordance with requirements specified by the laboratory's Analytical Chemistry Measurements

Team; changes in procedures are documented in writing. Samples analyzed as part of the USGS NRF sample program are containerized and preserved in accordance with requirements specified by TestAmerica Laboratories (2013) and GEL Laboratories, LLC (2015). Containers and preservatives for selected constituents are summarized in table 1.

Table 1. Containers and preservatives used for water samples, U.S. Geological Survey Idaho National Laboratory and vicinity.

[**Type of constituent:** VOCs, volatile organic compounds; C, carbon; H, hydrogen; O, oxygen; CFC, chlorofluorocarbon; HNO₃, nitric acid; HCl, hydrochloric acid; H₂SO₄, sulfuric acid; KOH, potassium hydroxide; °C, degrees Celsius. **Analyzing laboratory:** NWQL, U. S. Geological Survey's National Water Quality Laboratory; GEL, General Engineering Laboratory; RESL, U.S. Department of Energy's Radiological and Environmental Sciences Laboratory; RSIL, U.S. Geological Survey's Reston Stable Isotope Laboratory; ARS-ARS International, LLC; Test America-Eurofins Test America Laboratory; PRIME, Purdue Rare Isotope Measurement Laboratory. **Abbreviations:** mL, milliliter; L, liter; N, normal]

Type of constituent	Container		Preservative		Other treatment	Analyzing laboratory
	Type	Size	Type	Volume		
Anions, dissolved	Polyethylene	250 mL	None	None	Filter	NWQL
Anions, dissolved	Polyethylene	1 L	None	None	Filter	GEL
Cations, dissolved	Polyethylene, acid rinsed	250 mL	HNO ₃	2 mL	Filter	NWQL
Cations, total	Polyethylene, acid rinsed	500 mL	HNO ₃	2 mL	None	GEL
Metals, dissolved	Polyethylene, acid rinsed	250 mL	HNO ₃	2 mL	Filter	NWQL
Metals, total	Polyethylene, acid rinsed	250 mL	HNO ₃	2 mL	None	NWQL
Metals, dissolved	Polyethylene, acid rinsed	500 mL	HNO ₃	2 mL	Filter	GEL
Metals, total	Polyethylene, acid rinsed	500 mL	HNO ₃	2 mL	None	GEL
Mercury, dissolved	Glass, acid rinsed	250 mL	6N HCl	2 mL	Filter	NWQL
Mercury, total	Glass, acid rinsed	250 mL	6N HCl	2 mL	None	NWQL
Chromium, dissolved	Polyethylene, acid rinsed	250 mL	HNO ₃	2 mL	Filter	NWQL
Nutrients, dissolved	Polyethylene, brown	125 mL	None	None	Filter, chill, 4°C	NWQL
Nutrients, dissolved	Polyethylene, acid rinsed	125 mL	H ₂ SO ₄	2 mL	Chill, 4°C	GEL
Nutrients, total	Polyethylene, acid rinsed	125 mL	H ₂ SO ₄	2 mL	Chill, 4°C	GEL
VOCs	Glass, baked	40 mL (3)	None	None	Chill, 4°C	NWQL
VOCs	Glass	40 mL (3)	C ₆ H ₈ O ₆	25 mg	Chill, 4°C	GEL
Semi-VOCs	Glass, baked	1 L (2)	HCl	4 mL/bottle	Chill, 4°C	Test America
Gross alpha/beta-particle	Polyethylene, acid rinsed	500 mL	HNO ₃	2 mL	None	RESL
Nickel-63	Polyethylene, acid rinsed	2 L	HNO ₃	4 mL	None	GEL
Strontium-90	Polyethylene, acid rinsed	2 L	HNO ₃	4 mL	None	GEL
	Polyethylene, acid	500 mL	HNO ₃	2 mL	None	RESL

Type of constituent	Container		Preservative		Other treatment	Analyzing laboratory
	Type	Size	Type	Volume		
Gamma spectroscopy	Polyethylene, acid rinsed	2 L	HNO ₃	4 mL	None	GEL
	Polyethylene, acid	500 mL	HNO ₃	2 mL	None	RESL
Tritium	Polyethylene	500 mL	None	None	None	NWQL
	Polyethylene	500 mL	None	None	None	RESL
Transuranics	Polyethylene	1 L	None	None	None	ARS
	Polyethylene, acid rinsed	1 L	HNO ₃	4 mL	None	RESL
Isotopic uranium	Polyethylene, acid rinse	1 L	HNO ₃	4 mL	Filter	Test America
O-18/O-16 and H-2/H-1	Glass, with polyseal cap	60 mL	None	None	None	RSIL
C-13/C-12	Glass, with plastic coating, polyseal cap	1 L	None	None	None	RSIL
Dissolved gases	Glass, with rubber stopper	150 mL	None	None	Relieve pressure w/needle	Reston CFC Laboratory
CFC-Age dating	Glass, with white plastic caps, aluminum foil liner	125 mL	None	None	None	Reston CFC Laboratory
Iodine-129	Polyethylene with polyseal cap	1 L	KOH and sulfurous acid	None	Filter	PRIME Lab

Field Equipment

Analytical and other associated equipment used in the field include pH meters, thermometers, multiparameter instruments, titrators for alkalinity measurements, peristaltic pumps, in-line disposable filter capsules with a 0.45-micron filter that is certified to be analyte free, and associated glassware. The analytical equipment is housed and usually operated in mobile field laboratories. The purpose of the mobile laboratories is threefold: (1) they provide a relatively clean area to measure field parameters while minimizing the potential for contamination or degradation of the samples from the wind, dust, rain, snow, and sunlight; (2) they are used as storage for sample and shipping containers, chemical reagents and preservatives, analytical instrumentation, and deionized water used for decontaminating equipment in the field; and (3) they provide a place where samples can be containerized, preserved, and placed in a secured refrigerator or transportation container within minutes after withdrawal from a well or stream.

The multiparameter instruments used to measure field water-quality parameters, such as pH, specific conductance, and dissolved oxygen are maintained and calibrated in accordance with procedures specified by the instrument manufacturer; calibration data are recorded in the water-quality personal computer field form (PCFF) (fig. 1) and in the instrument calibration logbook (fig. 2). Forms are reviewed twice a year by the INL Project Chief. Changes to equipment—for example, changing batteries or the dissolved oxygen membrane—is recorded in the instrument calibration logbook. An inventory of field equipment is given in appendix 7.

November 2006

U. S. GEOLOGICAL SURVEY GROUND-WATER QUALITY NOTES

FIELD ID USGS 1

NWIS RECORD NO _____

Station No. <u>USGS 432700112470801</u>	Station Name <u>02N 31E 35DCC1 USGS 1</u>
Sample Date <u>10/01/2019</u>	Mean Sample Time (watch) <u>10:57</u>
Sample Medium <u>(WG) Groundwater</u>	Sample Type <u>(9) Regular</u>
Sample Purpose (71999):	Purpose of Site Visit (50280):
Project No. <u>GR20YE009HZG500</u>	Project Name <u>INLPO</u>
Sampling Team <u>nm</u>	QC Samples Collected? <input type="checkbox"/>
	Team Lead Signature _____ Date _____

Temperature, air(Method:) 00020	5.7 deg C
Temperature, water(Method:Temperature, water, thermistor) 00010 THM01	14.6 deg C
Air pressure(Method:Atmospheric pressure, barometer) 00025 BAROM	636 mm/Hg
Specific cond at 25C(Method:Specific conductance sensor) 00095 SC001	320 uS/cm @25C
Air pressure(Method:Atmospheric pressure, barometer) 00025 BAROM	636 mm/Hg
Dissolved oxygen(Method:Diss oxygen, membrane electrode) 00300 MEMBR	2.33 mg/l
pH(Method:pH, wu, field, electrometry) 00400 EL003	8.06 std units

SAMPLING INFORMATION

Analysis Status (U) Unrestricted Pump/Sampler make/model: Grundfos 5 hp
 Hydrologic Condition (X) Not applicable Sampling Condition (72006)
 Hydrologic Event (X) Not applicable sample source (72005)
 Sample method (82398) (4040) Submersible pump
 Sampler Type (84164)

WEATHER

GW Clarity: Weather Partial Cloud cover Wind: Mild
 GW Odor: Temperature: Cool Est Wind Vel
 GW Color: Weather
 Comments

Sampling point description

Sample Contact
with:

☐ nitrogen ☐ Atmosphere
☐ other ☐ oxygen

Figure 1. Sample Personal Computer Field Form sheet.

Depth to set pump from MP (all units in feet)	
Distance to top of screen from LSD	
MP	
dia. factor of well	5"
DEPTH TO PUMP FROM MP	
DEPTH TO PUMP FROM LSD	

Sampling depth(00003/): **TD 630 ft**

WELL DATA

PURGE VOLUME

Calculated Purge Vol. , gal.

Flow rate, instant.(00059/): **20 gal/min**

Time pumped before sampling
(72004) **2 minutes**

Calculated
pump period: Min Min

FIELD OBSERVATIONS

Sampling point: 1/4" ss sample port, 5 hp sub pump

Water level: 594.51', pump on @ 1032

Control box @ 60 Hz (ccw)

Observers: none

Reference Number: 1910012

Field Sample Comments (for NWIS, 300 characters max.):

Sch 19 - 3H, Alpha/Beta, Na+, Cr, Cl-, SO4- -, NO3- (5)

QUALITY-CONTROL INFORMATION

QC sample associated with this
environmental sample (99111): [info_99111](#)

Purpose, Topical QC data (99112): [info_99112](#)

Replicate-sample type (99105): [info_99105](#)

Reference-material or spike source
code no. (99104): [info_99104](#)

Reference-material source (99103): [info_99103](#)

Blank-solution type (99100): [info_99100](#)

Source of blank water (99101): [info_99101](#)

Blank-sample type (99102): [info_99102](#)

Spike-sample type (99106): [info_99106](#)

Spike-solution source (99107) : [info_99107](#)

Spike-solution volume, mL (99108): [info_99108](#)

Figure 1.—Continued

Temperature, water -Temperature, water, thermistor (00010/THM01)Mtr W-no. or thermometer no. QD02194

Date NIST/ASTM checked:

Temperature subsample from or measurement location: Flow-thru chamber

MEDIAN:

RMK

Qualifier

Field Readings 14.5 14.6 14.6 14.6 14.614.6 deg C**pH -pH, wu, field, electrometry (00400/EL003)**METER MAKE/MODEL: S/N QD02194

Thermister Check:

pH subsample from or measurement location: Flow-thru chamber

Temp	Initial Read	Calibrated?	After Adj.	Slope	Millivolts
		<input type="checkbox"/>			
		<input type="checkbox"/>			
		<input type="checkbox"/>			

MEDIAN:

RMK

Qualifier

Field Readings 8.34 7.98 8.04 8.06 8.07 8.06**Specific cond at 25C -Specific conductance sensor (00095/SC001)**

METER MAKE/MODEL

S/N QD02194

Thermister Check:

Sample: Flow-thru chamber

Temp	Initial Read	Calibrated?	After Adj.	pct. error
		<input type="checkbox"/>		
		<input type="checkbox"/>		
		<input type="checkbox"/>		

Correction Factor:

MEDIAN

RMK

Qualifier

Field Readings 311 322 320 320 318320 uS/cm @25C**Dissolved oxygen -Diss oxygen, membrane electrode (00300/MEMBR)**

METER MAKE/MODEL

S/N QD02194

Thermister Check Date:

D.O. Zero Check Date:

Calibration :

Sample: Flow-thru chamber

CALIB. TEMP °C	BAROMETRIC PRESSURE mm Hg	DO TABLE READING mg/L	SALINITY CORR FACTOR	DO BEFORE ADJ.	DO AFTER ADJ.
-------------------	---------------------------------	-----------------------------	----------------------------	----------------------	---------------------

FIELD READINGS 2.73 2.31 2.36 2.33 2.31MEDIAN
2.33 mg/l

RMK

Qualifier

Calibration Notes and Remarks**Figure 1.—Continued**

Date _____ Employee Name _____

pH Calibration

Step	Buffer Circle one	Lot #	Exp. Date	Buffer Temp	Initial Reading	Adjusted Reading	End of Day Check Value
1 calibrate	7			°C			
2 set slope	4 or 10			°C			
3 check	10 or 4			°C			
Special				°C			
Special				°C			

Specific Conductance Calibration

Standard Value	Lot #	Exp. Date	Standard Temp	Initial Reading	Adjusted Reading	End of Day Check Value
			°C			
			°C			
			°C			

Dissolved Oxygen Calibration

Method

- ☐ Air Calibration in Water
☐ Air Calibration Chamber in Air
☐ Air-Saturated Water
☐ Calibration by Winkler Titration

Measurement	Initial
Barometric Pressure	mmHg*
Temperature	°C
D.O. Saturation or Winkler	mg/L
Meter reading	mg/L
Meter adjusted to	mg/L

*mm=inches x 25.4

Remarks and Repairs

Figure 2. Sheet from instrument calibration logbook.

LOCATION=	1 OF 1
SAMPLER =	SPEC COND =
STA TION NAME =	TIME =
DATE =	pH =
SAMP LE SIZE =	TREATMENT =
REF NUMBER =	AIR TEMP =
WATER TEMP =	SCHEDULE =
SAMPLE TYPE =	

Figure 3. Label attached to each sample bottle.

Calibration Procedure for pH

The INL Project Office personnel calibrates pH meters each day during which water-quality samples are collected. Calibration of the meter can be performed in the laboratory or at the first well site where water-quality samples are collected that day. The calibration standards are warmed or chilled to a temperature similar to well temperatures measured for the day. The calibration data are recorded in the instrument calibration logbook (fig. 2). If the calibration is done in the laboratory and the meter is then transported to the well site, the meter is checked with a pH 7 buffer prior to sampling if the pH differs by more than 0.2 pH units from the previous two readings recorded at the site. The meter is recalibrated if the 7 buffer check is off by more than 0.2 pH units. The pH also is checked for accuracy with a pH 7 buffer before sampling at each subsequent well if the initial readings taken at the new site differ by more than 0.2 pH units from the previous two readings recorded at the site. The measured value of the pH 7 buffer is recorded on the PCFF (fig. 1) for the appropriate site. A pH reading of the pH 7 buffer is taken after sampling the last site of the day for the end-of-day check and recorded in the instrument calibration logbook (fig. 2).

Calibration Procedure for Specific Conductance

The INL Project Office personnel calibrates specific conductance meters each day during which water-quality samples are collected. Calibration of the meters can be performed in the laboratory or at the first site where water-quality samples are collected that day, but temperature of the standards should be close to what will be measured. The calibration data are recorded in the instrument calibration logbook (fig. 2). If the calibration is done in the laboratory and the meter is then transported to the site, the specific conductance meter is checked with the appropriate buffer prior to sampling if specific conductance differs by more than 5 percent from the previous two field readings at the site. The buffer solution should have a specific conductance similar to the water that is being sampled. The specific conductance is also checked for accuracy with a buffer before sampling at each subsequent site where water-quality samples are collected if specific conductance differs by more than 5 percent from the previous two field readings. The measured value of the buffer is recorded in the water-quality PCFF (fig. 1) for the appropriate site. A specific conductance reading is taken after sampling the last well of the day for the end-of-day check, and the reading is recorded in the instrument calibration logbook (fig. 2). The specific conductance meter is recalibrated if at any time the reading of the buffer is off

by ± 5 percent for conductivity ≤ 100 $\mu\text{S}/\text{cm}$ or ± 3 percent for conductivity > 100 $\mu\text{S}/\text{cm}$ (U.S. Geological Survey, variously dated, chapter 6.3).

Calibration Procedure for Dissolved Oxygen

The INL Project Office personnel calibrates dissolved oxygen meters each day during which water-quality samples are collected. Calibration of the meters can be performed in the laboratory or at the first site where water-quality samples are collected that day. The temperature at the time of calibration is recorded in the instrument calibration logbook (fig.2). The temperature and the atmospheric pressure are used to obtain the solubility of oxygen in water (U.S. Geological Survey, variously dated, table 6.2-6). The meter will be checked throughout the day to make sure that there are no bubbles on the inside of the membrane and that there are no tears or wrinkles in the membrane. If bubbles are present or the membrane is damaged, the membrane is changed.

Decontamination Procedures

Wells that are equipped with dedicated submersible or line-shaft turbine pumps do not require decontamination except for the equipment that is attached to the discharge pipe to accommodate the collection of a water sample. However, one wellbore volume of water is pumped from the well to remove stagnant water and to rinse and equilibrate the pump and delivery line.

Sample collection is facilitated and excess water is diverted away from the well head by fitting wells equipped with dedicated pumps with a portable discharge pipe about 2 ft long. The discharge pipe has a 1.5-in. inside diameter and is equipped with a gate valve to control the flow rate. A series of joints, nipples, pipe sections, and valves to control the flow rate of the sampling ports are attached to the portable discharge line to enable splitting of the well discharge into three streams. The diameters of two of the streams are reduced to 0.25-in. and have Tygon™ tubing attached to the discharge pipe. The first tube is attached to a flow-through chamber used for measuring temperature, pH, specific conductance, and dissolved oxygen. The second tube is used for filling sample bottles. The third discharge stream is excess water and is diverted away from the well.

All fittings and pipes are stainless steel and are rinsed with deionized water before installation at the well head. For most wells, subsequent flushing with several hundred to thousands of gallons of purged well water further reduces the possibility of cross contamination with water from previously sampled wells. After sample collection, the fittings and pipes are rinsed with deionized water and capped prior to storage to further reduce the chance of cross contamination between wells. In an attempt to extend the longevity of pumps, a frequency reduction system is installed between the generator and the well pump to control the speed of the 5-horsepower pumps.

Production wells generally have a spigot at or near the well head and do not require special sample-collection equipment; decontamination consists of rinsing the spigot with pumped groundwater to remove foreign materials.

A bailer is used for collecting water samples from wells without dedicated pumps and wells with only a few feet of water in the wellbore. The bailer and the bailer line that enters the well are washed with water and detergent and rinsed with deionized water prior to use and rinsed with deionized water after use; samples of the rinsate are periodically collected and analyzed to

document whether the equipment is contaminated by constituents of interest. At all wells, bailers are dedicated to the wells, reducing the chance for cross-contamination.

At the sites sampled for vertical definition of contaminants in the aquifer, stainless-steel thief sampling devices (bottles) are used to collect samples. The sample is delivered directly from the stainless-steel thief sampling bottles to a precleaned container which is used for filling the appropriate sample containers. Prior to sampling at each sampling port, the stainless-steel thief sampling bottles are washed with water and detergent and rinsed with deionized water. At the end of the day, the equipment is washed with water and detergent and rinsed with deionized water prior to storage to further reduce the chance of cross contamination.

For surface-water sites, grab samples are collected from the bank of the stream, using either a pre-cleaned TeflonTM container, or precleaned churn splitter. Prior to sampling, the selected container is washed with water and detergent and rinsed with deionized water and rinsed with deionized water after collection.

Sample Collection

Sample collection by the USGS at the INL generally follows protocols outlined in the USGS National Field Manual (U.S. Geological Survey [variously dated, chap. A4]) or in the USGS Idaho Water Science Center Quality-Assurance Plan for water-quality activities (Chris Mebane and Rhonda Weakland, U.S. Geological Survey, written commun., 2016); however, protocols sometimes are modified to collect the best representative water sample possible. At wells equipped with a dedicated pump, a volume of water equivalent to a minimum of one wellbore volume is pumped prior to collecting the samples; at many wells, more than one wellbore volume is pumped because of the amount of time needed for three stable readings. The purging of one well volume instead of three as recommended in the USGS National Field Manual is done to limit the amount of purge water that needs to be containerized at some wells. Bartholomay (1993) and Knobel (2006) generally found that sample concentrations would not be affected by a change in the number of volumes of water purged for the wells evaluated. The diameter of the borehole, rather than the volume of the casing, is used to calculate the minimum volume because of the potentially great difference between the two. Additionally, temperature, specific conductance, pH, and dissolved oxygen are monitored periodically during pumping using methods described by Wood (1981), Hardy and others (1989), and U.S. Geological Survey (variously dated, chapter A6). Field measurements made immediately prior to sample collection are used to represent those for the sample. A water sample is collected when pH measurements are within ± 0.1 standard units, water temperature is ± 0.2 °C, and specific conductance readings are within 5 percent of each other for three consecutive readings taken 3–5 minutes apart, indicating probable hydraulic and chemical stability. Samples are collected using the following steps:

1. The field person responsible for collecting the water sample wears disposable gloves and stands in a position where neither the collector nor the sample can become contaminated.
2. The outside of the sample delivery line is thoroughly rinsed with water pumped from the well.
3. If appropriate, sample containers and filtration equipment are thoroughly rinsed with water pumped from the well or surface-water site before being used. A new, disposable capsule filter with a 0.45-micron-membrane filter is used at each site. The capsule filter is inverted to clear trapped air bubbles and two liters of deionized water is used to rinse the

capsule filter prior to sample collection. This removes any surfactants that are adhered to the filter.

4. For groundwater samples from wells equipped with dedicated pumps, the capsule filter is connected to the sample port with precleaned Tygon™ tubing; unfiltered samples are collected directly from the sample port. For surface-water samples, thief samples, and bailer samples, a grab sample is collected in a precleaned container and the precleaned inlet tubing of a peristaltic pump is placed into the container to supply sample water to the capsule filter. Unfiltered samples are collected by submersing the sample container into the surface-water body or drawing water from a precleaned container.
5. Samples are capped and moved into the mobile field laboratory where they are uncapped and preserved (if appropriate) as described in table 1. A new pair of gloves, safety glasses, and a laboratory apron are worn while preserving samples.
6. The bottles are capped. The bottles are then labeled (see fig. 3 for example of label). An alternate method for labeling containers is to record information directly on the sample container using a permanent marker. Recording the information both on a label and directly on the bottle is preferable.
7. Field measurements are made again after samples are collected. If the temperature differs by more than 0.5 °C, the pH differs by more than 0.1 units, or the specific conductance differs by more than 5 percent, the measurements are verified and a second set of samples is collected. The second set of samples replaces the original set of samples.
8. An analytical services request form is completed for use by each laboratory to which the sample(s) will be sent for analysis (see figs. 4–6 for examples).
9. The water samples are chilled to 4 °C if necessary and stored in the field laboratory until they can be transferred to a secured storage area. Samples are sent biweekly to the USGS NWQL and daily to TestAmerica and GEL Laboratories for analysis; the samples are transported in a sealed ice chest by a contract carrier and overnight delivery is stipulated for water samples for analyses of nutrients, VOCs, and other time-sensitive constituents. Samples sent to the RESL for analyses are hand carried to the laboratory at the end of the sampling event.
10. All equipment is decontaminated with deionized water and, if necessary, organic-free water.

ANALYTICAL SERVICES REQUEST
U.S. GEOLOGICAL SURVEY – NATIONAL WATER QUALITY LABORATORY

LAB USE ONLY			LAB USE ONLY										
SAMPLE ID NUMBER		User Code	Project Account										NWQL LABORATORY ID

Source Agency Code	Station ID	Begin Date	Begin Time	Medium Code
WBC Contact (email)	WBC Contact (phone)	End Date (if req'd)	End Time (if req'd)	Sample Type

SITE / SAMPLE / SPECIAL PROJECT INFORMATION (optional)

Check boxes as appropriate: ☐ Chain of Custody ☐ Hazard* ☐ USDA Soil ☐ Lab Spike ☐ Lab Filter

***Hazard Details:**

State	County	Hydr. Event	Hydr. Cond.
NWQL Proposal Number	Proposal Contact Email ID	Proposal Contact Phone #	Program/Project

Station Name: _____

Comments to NWQL: _____

SCHEDULES AND LAB CODES (SCHED = Schedule; LC = Lab Code; (A) = add or (D) = delete)

SCHED 1: _____ SCHED 2: _____ SCHED 3: _____ SCHED 4: _____ SCHED 5: _____ SCHED 6: _____

LC: _____ A D LC: _____ A D LC: _____ A D LC: _____ A D LC: _____ A D

LC: _____ A D LC: _____ A D LC: _____ A D LC: _____ A D LC: _____ A D

SHIPPING INFORMATION (Number of containers sent)

ALF	FA	GCC	POCIS-SPMD	SUSO	UAS
BGC	FAM	GCV	RA	TBI	WCA
CC	FAR	HFL	RAM	TBY	
CHL	FCA	HUN	RAR	TOC	
CU	FCC	MBAS	RCB	TPCN	
CUR	FCCVT	OXW	RU		
DIC	FU	PEST	SAS	RUR	Time: _____
DOC	FUS	PHARM	SUR	RURCV	Time: _____

NWQL Login Comments (Lab only): _____

Collected by Email: _____ Phone: _____ Ship Date: _____

FIELD VALUES

Lab/P Code	Value	Remark	Lab/P Code	Value	Remark	Lab/P Code	Value	Remark
21/00095			51/00400			2/39086		
Specific Conductance uS/cm @ 25 deg C			pH Standard Units			Alkalinity – IT mg/L as CaCO3		
101/00419			103/29813			102/29802		
ANC, unfiltered, incr			ANC, unfiltered, Gran			Alkalinity filtered, Gran		

NWIS RECORD NUMBER

Form 9-3094
(November 2017)

Figure 4. Analytical services request form for the National Water Quality Laboratory.

SAMPLE RECORD SHEET

Sample identifier	Reference date	Wt/vol units	Name	Site	Sample matrix	Special instructions	RESL analytes

Figure 5. Sample record sheet for the Radiological and Environmental Sciences Laboratory

U.S. GEOLOGICAL SURVEY – ANALYTICAL SERVICES REQUEST (ASR)

SAMPLE IDENTIFICATION									
LAB RECORD NUMBER							LAB USE ONLY		
SAMPLE TRACKING ID	User Code		Project Account				LABORATORY ID		
			Begin Date (YYYYMMDD)*		Begin Time*		Medium code*		Sample Type
			End Date (YYYYMMDD)		End Time		@usgs.gov		
STATION ID*			USGS Project Contact Email						
SITE / SAMPLE / PROJECT INFORMATION (Optional)									
State	County	Geologic Unit Code	Analysis Status	Analysis Source	Hydrologic Condition	Hydrologic Event	Turn Around Time Required		
<i>Note: State, County, and Geologic Unit Code data will not be entered in by Contract Laboratory</i>									
Lab Name & Ph.no.			Lab Contact Email			USGS Project Name			
Station Name or Field ID:									
Sample conditions or hazards:									
ANALYTICAL WORK REQUESTS: SCHEDULES AND CONTRACT ITEM NUMBERS (CINs)									
Note: Contract Item Numbers (CINs) are used as Lab Codes for this specific ASR.									
CIN	Filtered (F) or Unfiltered (U)	Analysis schedule(s) Remarks: list analytical method no., specific analytes for metals and anion analyses, special instructions, and other comments	Containers/Preservatives						
			Unpres.	H2SO4	HNO3	Ascorbic	HCl		
Please hold this water sample for 60 days after invoicing.									
CHAIN OF CUSTODY RECORD									
ASR: Relinquished by:		Date:		Time:					
ASR: Received by:		Date:		Time:					

USGS DODESP Contract ASR, revision 2.2, 01Oct2010

Figure 6. Sample request and chain-of-custody record for GEL Laboratories, LLC, and TestAmerica Laboratories.

Date: _____
 Calibrated by: _____

Make any notes (reason for calibration, when cable was replaced, maintenance, tape hung up in well, unusual cal checks)

WELL/NAME	STEEL TAPE #1 (1000 ft)			ETAPE 1 (sn 38303)		ETAPE 2 (sn1437380)		ETAPE 3 (sn 36592)		ETAPE 4 (sn1437381)		ETAPE 5 (sn36529)		ETAPE 6 (sn1637402)	
	STEEL TAPE HOLD FROM MP	STEEL TAPE CUT	STEEL TAPE READING FROM MP	ETAPE READING FROM MP	ETAPE CORRECTION	ETAPE READING FROM MP	ETAPE CORRECTION	ETAPE READING FROM MP	ETAPE CORRECTION	ETAPE READING FROM MP	ETAPE CORRECTION	ETAPE READING FROM MP	ETAPE CORRECTION	ETAPE READING FROM MP	ETAPE CORRECTION
USGS 55															
date/time															
USGS 61															
date/time															
USGS62															
date/time															
USGS 19															
date/time															
USGS 97															
date/time															
USGS 142															
date/time															
USGS 142A															
date/time															
USGS 120															
date/time															
USGS 146															
date/time															
USGS 8															
date/time															
CH1															
date/time															

Figure 7. Electronic tape calibration form.

Some wells completed in the perched-water zones do not contain or produce enough water to be sampled with a pump. For these wells, a 1,000-mL Teflon™ bailer is used for sample collection. The well is bailed until enough water is collected for all the samples required or until the well is bailed dry. When the bailer is retrieved, its contents are placed either directly in bottles for raw samples or in a precleaned container as described in step 4 above. Field measurements are made on excess water from the bailer or in the precleaned container. After the sample bottle is filled with either raw or filtered water, samples are preserved appropriately, labeled, stored, and shipped as described in steps 6, 8, and 9 above.

At the sites sampled for vertical definition of contaminants in the aquifer, the evacuated stainless-steel thief sampling devices (bottles) are lowered to the zone to be sampled, mated to the sampling port, and filled with formation water. The stainless-steel bottles are raised to the surface and emptied into a precleaned container; the water is processed to fill sample containers as described in step 4 above. Field measurements are made on excess water from the precleaned container. After the sample bottle is filled with either raw or filtered water, samples are preserved appropriately, labeled, stored, and shipped as described in steps 6, 8, and 9 above. This

process is repeated until sufficient water has been collected to fill all of the required sample containers and to make all necessary field measurements.

At sites where containerization of purge water is required, the sampling stream is split to accommodate measurement of the field-water-quality indicators (temperature, pH, specific conductance, and dissolved oxygen) and to collect samples. Additionally, excess purge water is collected at the discharge point in buckets that are subsequently emptied in the trailer-mounted containers and also routed through canvas hoses to the trailer-mounted containers. The containerized purge water is subsequently transported to an approved disposal site.

Wells inside the Advanced Test Reactor Complex and the boundary of the Resource Conservation and Recovery Act Listed Waste Polygon (Knobel, 2006) require containerization of all purge water. These wells are purged at slow rates to minimize the amount of purge water. After three stable readings of temperature, pH, specific conductance, and dissolved oxygen are obtained, and at least one wellbore volume has been purged, samples are collected.

Production wells at the INL generally are connected to water distribution systems, and they cycle on and off in response to system water demands. Because of the frequent pumping cycles, water in the system is representative of aquifer water, and only sample collection lines require purging prior to sampling. In many cases, the production wells cycle off before the multi-parameter field measurement instruments can stabilize. In this case, the requirement for stable readings is waived; however, an end of day check must be satisfactory, or the well is resampled.

Conditions at the well during sample collection are recorded in a PCFF (fig. 1), and the analytical services request forms (figs. 4–6) are used to track samples from the time of collection until delivery to the RESL or until mailing to the USGS NWQL, GEL Laboratories, LLC, TestAmerica Laboratories, or other labs used. These records are available for inspection at the USGS INL Project Office. The chain-of-custody record for the current NRF contract laboratories, GEL Laboratories, LLC and TestAmerica Laboratories, is shown in figure 6. The original is sent to the laboratory with samples and a copy is provided to the NRF.

Data Management for Water Quality

All valid data analyses are entered into the NWIS database. The method by which the data are entered varies with the capabilities of the laboratory that performed the analyses.

The USGS NWQL and other USGS laboratories format the analytical results into NWIS-compatible batch input files. An electronic copy of the data is sent to the Water Science Center via the QW-Data Transfer System for input to the NWIS. Following processing, the batch output files are made available for the appropriate field/project office or individual requestor.

Some contract laboratories will provide analysis results in spreadsheet format, tab-delimited text files, or paper copy. In these instances, the data are formatted into NWIS-compatible batch files or manually entered and checked for correctness by a second person. Field measurements made during sample collection and other pertinent metadata are manually entered once the laboratory data are available in NWIS.

Data management begins with a file for tracking requested analyses at each data collection site. This data-tracking file shows which analyses have been requested, if the data are available in the NWIS database and whether field parameters and other metadata have been entered. Data are validated by review for reasonableness by comparing to historical values and by utilizing the water-quality data checks function available through the NWIS Data Portal and Reports Application. Laboratory reruns may be requested for data results of questionable accuracy. When the data has been reviewed, the analyst can decide to accept or reject the results.

This decision is reflected by using the Data Quality Indicator (DQI) code in the NWIS database analytical record. In most instances, the DQI code is changed from presumed satisfactory (S) to reviewed and accepted (R). Water quality data are reviewed and accepted by the INL water quality database administrator generally within 150 days after the data are available in NWIS.

Field Methods for Water-Level Measurements

Calibration of water-level measurement equipment and use of appropriate field procedures are crucial in assuring reliable water-level data are collected from open boreholes, data loggers, and MLMS. All sites are surveyed with known measuring points and the water-level is calculated from a known land surface datum (LSD).

Calibration of Electric Tapes

The USGS INL Project Office started the use of e-tapes in 2003; prior to 2003, stainless steel tapes were used. E-tapes are calibrated against a reference steel tape that is maintained in the office for calibration use only. Calibration is conducted downhole in designated boreholes at various intervals that represent WL monitoring depths. All e-tapes are initially calibrated before use in the field and recalibrated annually or more frequently if it is used often or if the tape has been subjected to abnormal stress that may have caused it to stretch. With the establishment of the USGS internal policy GW2015.03 “Policy for quality assurance checks of steel and electric groundwater level measurement tapes,” the INL Project Office started sending tapes in for calibration at the Hydrologic (HIF) Instrumentation Facility. Results from HIF created several questions on reproducibility of the calibrations, so the INL Project Office decided to stay with current calibration procedures described here to maintain long-term data comparability. Discussion with HIF and the Water Science field team are included in appendix 9. An inventory of e-tapes is given in appendix 7. The following procedures modified from Cunningham and Schalk, 2011 are used for calibration and entered on a field calibration sheet (fig. 7):

1. Check the distance from the probe’s sensor to the nearest foot marker on the tape to ensure that this distance puts the sensor at the zero-foot point for the tape. If it does not, a correction must be applied to all depth-to-water measurements.
2. Check the circuitry of the electric tape before lowering the probe into the well by dipping the probe into tap water and observing whether the indicator light and beeper are functioning properly to indicate a closed circuit.
3. Compare water-level measurements made with the electric tape with those made with a reference steel tape in several wells that span the range of depths to water that is anticipated. Measurements should agree to within ± 0.02 foot. If measurements are not repeatable to this standard, then a correction factor based on a regression analysis is developed and applied to measurements made with the e-tape. The e-tape correction files are stored on the INL Project Office Server and posted on the corresponding e-tape.

Collection Procedures for Water Levels

All water-level measurements taken with an e-tape have a calibration and measuring point (MP) correction applied to them. Several wells also have deviation corrections applied; these corrections have been calculated from geophysical deviation log files. All data are entered in Site Visit Mobile Aquarius (SVMAQ) for electronic download and on a field sheet for back up (fig. 8).

1. Using the e-tape, make all readings using the same deflection point on the indicator scale, light intensity, or sound so that water levels will be consistent between measurements.
2. Lower the electrode probe slowly into the well until the indicator shows that the circuit is closed and contact with the water surface is made. Take a second reading to check measurement within +/- 0.02 ft. of each other at the known MP; this is the depth to water. Be sure you have a solid beep and verify the reading by lowering the tape in the water table you still have a solid beep. Record the depth to water, date and time of the measurement on the water level field sheet (fig. 8) and into SVMAQ for electronic download.
3. After completing the water level measurement, rewind the tape and rinse the end of the tape with deionized water prior to storing for travel to the next well.
4. Maintain the tape in good working condition by periodically checking the tape for breaks, kinks, and possible stretch.
5. When recording the water levels on the field sheet and into SVMAQ, apply the MP correction to get the depth to water in feet below LSD. All MP descriptions from NWIS are available in the SVMAQ program. Apply any deviation and e-tape corrections. View historic data and the hydrograph on the SVMAQ program to verify the water-level is reasonable.

January Water Levels

Well name	January	Measuring point	Deviation correction	Site identifier	Latitude longitude	Remarks	Etape reading	Date	Time	Water level (raw)
USGS 2	AQ	2.13	-0.3	433320112432301	433319.87 1124321.28					
USGS 5	AQ	1.60	NA	433543112493801	433542.75 1124937.65					
USGS 6	AQ	2.07	NA	434031112453701	434031.12 1124536.66					
USGS 7	AQ	1.68	NA	434915112443901	434914.81 1124439.87					
USGS 8	AQ	2.11	SEE CHART	433121113115801	433120.51 1131157.43					
USGS 11	AQ	2.34	NA	432336113064201	432336.18 1130642.52					
USGS 14	AQ	1.59	NA	432019112563201	432019.27 1125631.92					
USGS 15	AQ	1.33	NA	434234112551701	434234.84 1125517.35					
USGS 17	AQ	2.53	NA	433937112515401	433936.42 1125154.27					
USGS 18	AQ	1.78	NA	434540112440901	434540.70 1124409.29					
USGS 19	AM	2.08	NA	434426112575701	434426.68 1125756.58					
USGS 20	AQ	1.96	NA	433253112545901	433252.79 1125459.41					
USGS 22	AQ	1.69	-0.2	433422113031701	433422.28 1130321.09					
USGS 23	AQ	2.90	NA	434055112595901	434055.15 1130000.02					
USGS 26	AQ	2.10	NA	435212112394001	435210.55 1123940.74					
USGS 27	AM	2.26	NA	434851112321801	434851.22 1123218.90					
USGS 39	AQ	1.63	-0.2	433343112570001	433343.19 1125701.42					
USGS 54	PQ	1.67	NA	433503112572801	433503.00 1125728.00					
USGS 2	AQ	2.13	-0.3	433320112432301	433319.87 1124321.28					
USGS 55	PQ	1.72	NA	433508112573001	433508.00 1125729.00					
USGS 57	AQ	2.21	NA	433344112562601	433344.04 1125626.00					
USGS 60	PQ	2.06	NA	433456112571901	433456.00 1125719.00					
USGS 61	PQ	0.66	NA	433453112571601	433453.00 1125715.00					
USGS 62	PQ	1.86	NA	433446112570701	433446.00 1125705.00					
USGS 63	PQ	1.76	NA	433455112574001	433455.00 1125740.00					
USGS 65	AQ	0.83	NA	433447112574501	433446.85 1125747.13					
USGS 66	PQ	1.80	NA	433436112564801	433439.00 1125657.00					

Figure 8. Sample water level field sheet.

January Water Levels

USGS 68	PQ	3.16	NA	433516112573901	433516.00 1125740.00					
USGS 69	PQ	2.47	NA	433450112573001	433450.00 1125729.00					
USGS 70	PQ	2.16	NA	433504112571001	433504.00 1125710.00					
USGS 71	PQ	1.52	NA	433439112571501	433439.00 1125714.00					
USGS 72	PQ	2.00	NA	433519112574601	433519.00 1125747.00					
USGS 73	PQ	3.90	NA	433502112575401	433502.00 1125753.00					
USGS 78	PM	1.06	NA	433413112573501	433413.00 1125735.00					
USGS 82	AQ	1.77	NA	433401112551001	433400.93 1125510.34					
USGS 83	AQ	2.67	NA	433023112561501	433023.03 1125615.28					
USGS 84	AQ	1.96	NA	433356112574201	433356.51 1125741.84					
USGS 85	AQ	2.53	NA	433246112571201	433246.23 1125711.89					
USGS 2	AQ	2.13	-0.3	433320112432301	433319.87 1124321.28					
USGS 86	AQ	2.23	NA	432935113080001	432934.79 1130801.44					
USGS 89	AQ	1.88	NA	433005113032801	433005.67 1130331.73					
USGS 92	PQ	10.61	NA	433000113025301	433000.00 1130253.00					
USGS 97	AM	1.78	NA	433807112551501	433806.77 1125516.76					
USGS 100	AQ	2.19	NA	433503112400701	433502.72 1124006.67					
USGS 101	AQ	2.20	SEE CHART	433255112381801	433255.75 1123819.91					
USGS 104	AQ	2.99	NA	432856112560801	432856.07 1125608.14					
USGS 116	AQ	2.55	SEE CHART	433331112553201	433331.55 1125532.67					
USGS 120	AM	1.65	SEE CHART	432919113031501	432919.19 1130314.01					
USGS 125	AQ	2.20	SEE CHART	432602113052801	432559.41 1130530.37					
USGS 126B	AQ	1.20	NA	435529112471401	435528.51 1124713.67					
USGS 127	AQ	1.79	NA	433058112572201	433058.28 1125722.04					
USGS 130	AQ	1.44	NA	433130112562801	433130.67 1125628.40					
USGS 139A	AQ	1.47	NA	433823112460402	433823.23 1124603.58					
USGS 139B	AQ	1.46	NA	433823112460401	433823.23 1124603.58					
USGS 142	AM	0.96	NA	433837113010901	433837.32 1130109.41					

Figure 8.—Continued

January Water Levels

USGS 142A	AM	0.83	NA	433837113010902	433837.53 1130109.04					
USGS 143	AQ	2.83	NA	433736112341301	433735.71 1123412.78					
USGS 145A	AM	1.08	NA	433358113042702	433358.24 1130423.97					
USGS 2	AQ	2.13	-0.3	433320112432301	433319.87 1124321.28					
USGS 145B	AM	1.11	NA	433358113042701	433358.24 1130426.97					
USGS 147	AM	3.15	NA	432851113001401	432850.87 1130014.19					
USGS 148A	AM	2.49	NA	433535112390801	433535.42 1123907.52					
ANP 9	AQ	2.18	NA	434856112400001	434855.71 1124000.36					
ARA-MON-A-002	AQ	3.01	NA	433054112492102	433054.00 1124921.00					
ARBOR TEST	AQ	2.00	NA	433509112384801	433508.92 1123848.01					
CFA LF 2-10	AQ	1.43	-0.73	433216112563301	433215.87 1125632.97					
COREHOLE 1	AQ	2.52	NA	432927112410101	432926.76 1124100.07					
COREHOLE 2A	AQ	1.17	NA	434558112444801	434557.13 1124448.98					
ICPP-MON-A-166	AQ	2.38	NA	433300112583301	433300.12 1125833.19					
ICPP-MON-V-200	PQ	3.48	NA	433321112581501	433321.28 1125815.03					
MTR TEST	AM	1.30	NA	433520112572601	433520.08 1125729.20					
NO NAME 1	AQ	1.73	NA	435038112453401	435038.79 1124532.76					
NPR TEST	AQ	2.10	NA	433449112523101	433449.43 1125231.26					
NRF 15-A	AM	2.13	NA	433942112545002	433942.18 1125450.60					
NRF 15-B	AM	2.03	NA	433942112545001	433942.18 1125450.60					
PW 8	PQ	1.88	NA	433456112572001	433456.00 1125720.00					
PW 9	PQ	1.69	NA	433500112575401	433501.00 1125755.00					
SITE 9	AQ	2.00	NA	433123112530101	433122.86 1125300.80					

Figure 8.—Continued

January Water Levels

USGS 2	AQ	2.13	-0.3	433320112432301	433319.87 1124321.28					
SITE 14	AQ	2.23	NA	434334112463101	434334.66 1124631.50					
SITE 17 (remove AM wh)	AM	1.63	NA	434027112575701	434026.74 1125756.50					
RMS entry needed										
Monthly totals	79									
Sampled wells	0									
W/L's only	79									
AA-Aquifer well measured annually.										
AM-Aquifer well measured monthly.										
ANRF-Aquifer well measured for NRF										
AS-Aquifer well measured semi-annually.										
AQ-Aquifer well measured quarterly.										
PA-Perched well measured annually										
PM-Perched monthly										
PS-Perched well measured semi-annually.										
PQ-Perched well measured quarterly										
R-Well equipped with continuous water-level recorder.										
S-Water sample collected										
SBA-Water sample collected biannually										

Figure 8.—Continued

Calibration and Collection Procedures of Submersible Pressure Transducer and Data Loggers

Water-level measurements for pressure transducers will be made to the nearest 0.01 foot. The accuracy of a pressure transducer differs with the manufacturer, measurement range, and depth to water. The measurement error and accuracy standard for most situations for the transducer is 0.01 foot. Pressure transducers are subject to drift, offset and slippage of the suspension system. For this reason, the transducer readings are checked against the water level in the well on every visit, and the transducer is recalibrated periodically according to manufacturer specifications.

The USGS INL Project office maintains nine vented pressure transducers in observation wells for long-term continuous monitoring of water levels. These wells are scheduled for quarterly visits in order to download the data and calibrate the transducers. The procedure (Cunningham and Schalk, 2011) for retrieving water-level measurements from pressure transducers and maintaining the pressure transducers is:

1. Retrieve groundwater data by using instrument or data-logger software.
2. Inspect the equipment to confirm that installation is operating properly. Document the current water level recorded by the sensor.

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Data Management for Water Levels

The INL project office works by the USGS WMA water level data processing records management system of “Operator,” “Analyst,” and “Approver.” The Operator is the person assigned to make site visits and collect field data and often serves as the Analyst. Records will be analyzed for discrete periods of time by a hydrographer (the Analyst); more than one Analyst may be needed in some situations. A second hydrographer (the Approver) will examine the analysis and either approve the record, or returns it to the Analyst, informing them of what needs to be resolved in order for the records to be approved. After data are approved, any additional examination of groundwater-level records will be considered an audit.

Discrete groundwater-level records are stored in the Groundwater Site Information System (GWSI) where the data aging codes are: ‘In Review, presumed satisfactory’ (S), ‘Reviewed and Accepted, approved’ (R), and ‘Rejected’ (Q). While groundwater-level records are stored in GWSI, records should remain coded as ‘In Review,’ equivalent to the new ‘working’ state, until they have been analyzed according to guidelines and they are either approved or rejected (GW2017.04 Policy and Procedures for Processing and Publishing Discrete Groundwater-Level Records). Non-routine auditing is done within the Water Science Center and new procedures are in process for Internal Technical Review Procedures (ITRP’s).

The INL Operator utilizes SVMAQ for field groundwater data entry and processing as recommended by the USGS WMA. The use of mobile technology improves workflow processes in the collection, processing, and quality assurance of our groundwater data. The Analyst should begin analyzing and processing the SVMAQ .xml files as soon as practical after the field visit, ideally within 1 week of completing field work. When the field trip is processed the .xml files are archived on the INL Project Office server. The Approver will check field notes, possible errors, applied corrections and upload the .xml file to GWSI. All water level data are considered provisional data, ‘In Review, presumed satisfactory,’ (S) until it has been reviewed and approved. The Approver then reviews hydrographs and approves data (R). At this stage the Operator completes a Station Analysis report for the period of analysis in the Record Management System (RMS).

The INL Operator collects multilevel pressure measurements on an electronic field form that is reviewed. The Analyst should begin analyzing and processing the files as soon as practical after the field visit, ideally within 1 week of completing field work. When the field trip is processed the .xml files are archived on the INL Project Office server. The Approver will check field notes, possible errors, applied corrections and upload a batch file to GWSI. All water level data are considered provisional data, ‘In Review, presumed satisfactory,’ (S) until it has been reviewed and approved. Approver then reviews hydrographs and approves data (R).

Multilevel pressure measurements are calculated and reviewed. The processed data are uploaded to NWIS. The data are reviewed and approved by at least 120 days after collection.

Time-series data are stored in Aquarius where the data aging codes are:

1. Working: Raw data collected and entered into NWIS are in the working data state. These data are as accurate as possible following current best practices and in compliance with Technical Office and Water Mission Area policies for collection and database entry. Working data are displayed on NWISWeb as “Provisional.”
2. Analyzed: The analyzed state is defined as fully processed time-series data following current guidelines. Analysis of the data should begin as soon as practical after the field visit. If, during the analysis of a period, it is determined that there are insufficient data to

complete the analysis, the data state will remain as working until additional data are collected and issues are resolved. Analyzed records must have a complete station analysis for the analysis period. Analyzed data are labeled as such in the records management system and displayed on NWISWeb as “Provisional.”

3. Approved: The approved data state is defined as completely analyzed water-level data, including examination for errors and proper interpretation. Following full resolution of any problems identified, the record is set to Approved by a second hydrographer. Approved data are labeled as such in the records management system, shown in GWSI as “Reviewed and Accepted, approved,” and displayed on NWISWeb as “Approved” and are considered “published.”

Non-routine Auditing of Groundwater-Level Records: Non-routine audits occur anytime an aspect of an approved record is re-examined. For example, an end user may question a published period of unusually low water levels or a series of spikes in the historic water-level record. Errors found during non-routine audits are subject to defined error threshold criteria for revisions. Non-routine audits do not have any required tasks aside from documentation of the audit to include the date of the audit, the auditor, the data examined, the reason it was examined, and the outcome of the audit to include a discussion of potential revisions, if any. Another example of a non-routine audit would be a record that is examined during a triennial discipline review. In this case, most aspects of a designated analysis period are examined (superficially or in detail), and the documentation should include the notes or forms that were filled out by the reviewer. Non-routine audits are to be documented by filling out the Audit Template in RMS.

The INL Operator downloads the data logger files in comma-separated values (csv) format. The Analyst archives the .csv file on the INLPO server and uploads the file to Aquarius where it is set to working. The Analyst reviews the period of record, applies corrections to discrete water levels, examines the instantaneous values record, and edits it as needed. The initial instantaneous values cleanup includes checking thresholds set in the database and removing poor values such as spikes that were not automatically removed by thresholds. Water level data does not estimate missing instantaneous or daily values. When the Analyst has completed processing, the period of record is set to analyzed and they update the Station Analysis report for the period of analysis in the RMS. The Approver must be someone other than the operator/analyst that performs a quality-control check of the methods and procedures and verifies the accuracy and interpretations of the period of record. Any needed corrections are documented in RMS and returned to the Analyst. After verifying that corrections and edits are complete and evaluating hydrograph comparisons, the period of record is approved in Aquarius and RMS. Water levels are reviewed and approved within a 2-month period after they are collected.

Quality Assurance for Water Quality Activities

The USGS Quality-Assurance Program at the INL Project Office incorporates the previously described methods of sample collection and processing with several other elements:

1. Analytical methods used by the laboratories;
2. quality-control samples and data-quality objectives;
3. review of analytical results of chemical constituents provided by the laboratories;
4. audits of performance in the field and in the laboratory;
5. corrective actions to resolve problems with field and laboratory methods;
6. reporting of data; and

7. training and site safety requirements for personnel.

These elements are included to assure the following:

1. Reliability of the water-quality data;
2. Compatibility of the data with data collected by other organizations at the INL; and
3. Applicability of the data to the programmatic needs of the DOE, its contractors, and the scientific and regulatory communities.

Analytical Methods and Quality-Control Samples

Analytical methods used by the USGS NWQL for selected organic and inorganic constituents are described by Goerlitz and Brown (1972), Thatcher and others (1977), Skougstad and others (1979), Wershaw and others (1987), Fishman and Friedman (1989), Faires (1993), Fishman (1993), and Rose and Schroeder (1995). Additional publications that describe some analytical methods currently used at the USGS NWQL can be found at [NWQL](#). Other analytical methods from the U.S. Environmental Protection Agency (USEPA) that are currently used at the USGS NWQL can be found at [at the EPA website](#). Analytical methods from ASTM International that are currently used at the USGS NWQL can be found at <http://www.astm.org>. The type of analysis and the analytical procedure are specified on the USGS NWQL analytical services request form (fig. 4).

A discussion of procedures used by the RESL for the analysis of radionuclides in water is provided by Bodnar and Percival (1982) and the U.S. Department of Energy (1995). The type of analysis to be performed on a water sample is specified on the RESL sample submittal sheet (fig. 5).

A discussion of procedures and quality control used by NRF laboratories (Test America, GEL, and ARS International) is given in appendix 5. The laboratory request form for the NRF laboratories is given in figure 6.

A detailed description of internal quality control and of the overall quality-assurance practices used by the USGS NWQL is provided by Friedman and Erdmann (1982) and Pritt and Raese (1995); quality-control practices at the laboratory are described by Jones (1987); and quality-assurance data for routine water analyses are presented in Maloney and others (1993, 2005) and Ludtke and others (2000). Quality-control samples collected by the INL Project Office includes collection and analysis of the following:

1. Duplicate samples—two or more samples collected concurrently or sequentially and sent to different laboratories;
2. Replicate samples—samples with the same sample identification numbers submitted to a laboratory;
3. Source solution blank samples—samples of deionized water, organic-free water, or inorganic-free water sent to a laboratory;
4. Equipment blanks—rinsate collected from bailers and thief samplers during decontamination procedures;
5. Field blanks, samples of deionized water, organic-free water, or inorganic-free water pored in bottles in the field;
6. Splits—large sample volumes divided into two or more equal volumes and sent to different laboratories for analysis;
7. Trip blanks—laboratory supplied samples of boiled deionized water that travel with water samples from time of collection to time of analysis; and

8. Spiked samples—samples to which a known concentration of a constituent is added.

Generally, about 10 percent of the samples collected are dedicated to quality assurance. That is, for every 10 samples submitted to one of the laboratories for analysis, at least one is a replicate, a blank, a spike, or another type of quality-assurance sample. For samples that are to be analyzed for non-routine constituents, 15–20 percent of the samples are dedicated to quality assurance.

Comparative studies to determine agreement among analytical results for water-sample pairs analyzed by laboratories involved in the INL Project Office quality-assurance program are summarized by Wegner (1989), Williams (1996, 1997), Williams and others (1998), Knobel and others (1999), Carkeet and others (2001), Swanson and others (2002, 2003), Rattray and Campbell (2004), Rattray and others (2005), Rattray (2012), Davis and others (2013), Rattray (2014), Bartholomay and others (2015), Bartholomay and others (2017), and Bartholomay and others (2020). Additional quality-assurance studies by personnel at the INL Project Office include an evaluation of field-sampling and preservation methods for strontium-90 (Cecil and others, 1989), a comparison of different pump types used for sampling VOCs (Knobel and Mann, 1993), an analysis of tritium and strontium-90 concentrations in water from wells after purging different borehole volumes (Bartholomay, 1993), an analysis of the effect of different preservation methods on nutrient concentrations (Bartholomay and Williams, 1996), an analysis of two analytical methods for the determination of gross alpha- and beta-particle radioactivity (Bartholomay and others, 1999), and an evaluation of well-purging effects on water-quality of samples collected from the ESRPA (Knobel, 2006).

Data-Quality Objectives

Data-quality objectives are qualitative and quantitative criteria that describe the data needed by (1) managers or regulators to support environmental decisions and actions or (2) scientists to study natural or induced chemical processes in the eastern Snake River Plain aquifer. The first steps of the scientific method are somewhat analogous to, and supported by, data-quality objectives. Identifying problems is followed by hypothesizing solutions. Unbiased and thorough scientific experiments are proposed and then conducted, analyzed, and reported in the literature for peer review and use by others.

Laboratory data-quality objectives for routine water samples analyzed by the USGS NWQL are included in appendix 3, and data-quality objectives for radionuclides in water samples analyzed by the RESL are in appendix 4. Quality control requirements for GEL laboratories, LLC is given in appendix 5. Data-quality objectives for quality control data (includes both field and laboratory procedures for replicates and blanks) are included in appendix 6.

Review of Analyses

After the analytical results are obtained from the analyzing laboratory, the concentration of each constituent is reviewed by personnel at the INL Project Office for consistency, variability, and bias. Factors considered during the review are:

- The historical concentration of the solute at the site where the sample was collected;
- The concentration of the solute in replicate, split, blank, or other quality-assurance samples;

- The concentrations of the solute in nearby wells that obtain water from the same aquifer or perched-water zone;
- A review of waste-disposal records and changes in disposal techniques, land use, and recharge that may influence the concentration of a solute(s);
- Cation-anion balance of analyses for which common ions are analyzed; and
- Other accepted tests for accuracy of analytical results, when appropriate (Hem, 1985, p. 163–165).

Constituents for which previous analyses have been made are reviewed for consistency with the first three factors. Under certain circumstances, a re-analysis by the laboratory is requested or a second sample is collected and analyzed to verify the concentration of the solute in the water. These circumstances include:

1. A constituent differs from historical data,
2. A constituent differs markedly from the concentrations in water from nearby wells, or
3. An initial analysis for a solute exceeds 80 percent of the maximum contaminant level (MCL) for that constituent set by the USEPA.

If resampling is necessary, replicates or split samples generally are collected to evaluate field and laboratory variability. Spiked and reference samples are used to measure bias. Constituents for which MCLs have been proposed or established are shown in tables 2–6.

If analytical results indicate that concentrations in samples from one site vary by more than 50 percent from historical record for no obvious reason, reruns are requested and the results are evaluated by replicate sampling during the next sample period. If the analytical results for the replicates do not agree, the source of the discrepancy is investigated.

Table 2. Maximum contaminant levels of types of radioactivity and selected radionuclides in water.

[The maximum contaminant levels were established pursuant to the recommendations of the U.S. Environmental Protection Agency (2020) for community water systems and are included for comparison purposes only. The maximum contaminant level given for gross alpha-particle radioactivity includes radium-226 but excludes radon and uranium. The maximum contaminant level given for gross beta-particle and gamma radioactivity excludes radioactivity from natural sources and is included for comparison purposes only. Maximum contaminant levels given for strontium-90 and tritium are average concentrations assumed to produce a total body or organ dose of 4 millirem per year of beta-particle radiation. **Abbreviations:** mrem/yr, millirem per year; pCi/L, picocurie per liter; µg/L, microgram per liter]

Radionuclide or type of radioactivity	Maximum contaminant level
Gross alpha-particle radioactivity	15 pCi/L
Gross beta-particle and gamma radioactivity	4 mrem/yr
Iodine-129	1 pCi/L
Strontium-90	8 pCi/L
Tritium	20,000 pCi/L
Uranium	30 µg/L

Table 3. Maximum contaminant levels, secondary maximum contaminant levels, and reporting levels of selected trace elements in water.

[The maximum contaminant levels are for total measurements and were established pursuant to the recommendations of the U.S. Environmental Protection Agency (2020) for community water systems and are for comparison purposes only. Secondary maximum contaminant levels—shown in brackets—are from U.S. Environmental Protection Agency (2020). The reporting levels are taken from the Laboratory Information Management System used by the National Water Quality Laboratory, U. S. Geological Survey. More than one reporting level is given for constituents analyzed by different schedules (see app. 1). Units are in micrograms per liter (µg/L). **Symbols:** MCL, maximum contaminant levels; –, maximum contaminant level has not been established; *¹, copper has as action level of 1,300 µg/L; *², lead has as action level of 15 µg/L; SMCL secondary maximum contaminant levels]

Trace element	MCL [SMCL]	Reporting level
Aluminum	[50–200]	3.0
Antimony	6	0.06
Arsenic	10	0.1
Barium	2,000	0.01; 0.6
Beryllium	4	0.01
Boron	–	2.0
Cadmium	5	0.03
Chromium	100	1.0; 0.5
Cobalt	–	0.03
Copper	* ¹	0.4
Iron	[300]	10
Lead	* ²	0.02
Lithium	–	0.15
Manganese	[50]	0.4
Mercury	2	0.005
Molybdenum	–	0.05
Nickel	–	0.2
Selenium	50	0.05
Silver	[100]	0.03; 1.0
Strontium	–	0.5
Thallium	2	0.04
Uranium	30	0.03
Vanadium	–	0.1
Zinc	[5,000]	2.0

Table 4. Maximum contaminant levels, secondary maximum contaminant levels, and reporting levels of selected common ions in water.

[The maximum contaminant levels are for total measurements and were established pursuant to the recommendations of the U.S. Environmental Protection Agency (2020) for community water systems and are for comparison purposes only. Secondary maximum contaminant levels—shown in brackets—are from U.S. Environmental Protection Agency (2020). The reporting levels are taken from the Laboratory Information Management System used by the National Water Quality Laboratory, U. S. Geological Survey. Bromide’s reporting level is based on the method detection level; others are based on long term method detection levels. Units are in milligrams per liter (mg/L). **Abbreviations and symbols:** MCL, maximum contaminant levels; SMCL, Secondary maximum contaminant levels; –, maximum contaminant level has not been established]

Constituent	MCL [SMCL]	Reporting level
Bromide	–	0.01
Calcium	–	0.022
Chloride	[250]	0.02
Fluoride	4.0 [2.0]	0.004
Magnesium	–	0.01
Potassium	–	0.3
Silica	–	0.05
Sodium	–	0.4
Sulfate	[250]	0.02

Table 5. Maximum contaminant levels and reporting levels of selected nutrients in water.

[The maximum contaminant levels are for total measurements and were established pursuant to the recommendations of the U.S. Environmental Protection Agency (2020) for community water systems and are for comparison purposes only. The reporting levels are taken from the Laboratory Information Management System (LIMS) used by the National Water Quality Laboratory, U. S. Geological Survey. Reporting levels for nitrite and nitrite plus nitrate are based on method detection levels; others are based on long term method detection levels. Units are in milligrams per liter (mg/L). **Symbol:** –, maximum contaminant level has not been established]

Constituent	MCL	Reporting level
Ammonia (as nitrogen)	–	0.01
Nitrite (as nitrogen)	1	0.001
Nitrite plus nitrate (as nitrogen)	10	0.04
Orthophosphate (as phosphorus)	–	0.04

Table 6. Maximum contaminant levels and minimum reporting levels of selected volatile organic compounds in water.

[Analyses performed by the U. S. Geological Survey National Water Quality Laboratory using an analytical method equivalent to U.S. Environmental Protection Agency method 524.2. MCL's were established pursuant to the recommendations of the U. S. Environmental Protection Agency (2020) for community water systems and are included for comparison purposes only. MRL's are from the Laboratory Information Management System (LIMS) used by the National Water Quality Laboratory, U. S. Geological Survey. Units are in micrograms per liter (µg/L).

Abbreviations: MCL, maximum contaminant level; MRL, minimum reporting level. **Symbols:** –, MCL has not been established or proposed; *, total trihalomethanes-which include bromoform, chlorodibromomethane, chloroform, and dichlorobromomethane-in community water systems serving 10,000 or more persons cannot exceed 80 µg/L (U.S. Environmental Protection Agency, 2020)]

Compound	MCL	MRL	Compound	MCL	MRL
Acrylonitrile	–	2.5	Trichloroethylene (-ethene)	5	0.1
Benzene	5	0.1	Trichlorofluoromethane	–	0.2
Bromobenzene	–	0.2	Trichloromethane (Chloroform)	*	0.1
Bromochloromethane	–	0.2	Vinyl chloride	2	0.2
Bromodichloromethane	*	0.2	Xylenes, all isomers	10,000	0.3
Bromomethane	–	0.3	1,1,1,2-Tetrachloroethane	–	0.2
Butylbenzene	–	0.2	1,1,1-Trichloroethane	200	0.1
Chlorobenzene (mono-)	100	0.1	1,1,2,2-Tetrachloroethane	–	0.2
Chloroethane	–	0.2	1,1,2-Trichloroethane	5	0.2
Chloromethane	–	0.2	1,1,2-Trichlorotrifluoroethane	–	0.1
cis-1,2-Dichloroethene (-ethylene)	70	0.1	1,1-Dichloroethane	–	0.1
cis-1,3-Dichloropropene	–	0.2	1,1-Dichloroethene (-ethylene)	7	0.1
Dibromochloromethane	*	0.2	1,1-Dichloropropene	–	0.2
Dibromomethane	–	0.2	1,2,3-Trichlorobenzene	–	0.2
Dichlorodifluoromethane	–	0.2	1,2,3-Trichloropropane	–	0.2
Dichloromethane	5	0.2	1,2,4-Trichlorobenzene	70	0.2
Ethylbenzene	700	0.1	1,2,4-Trimethylbenzene	–	0.2
Hexachlorobutadiene	–	0.2	1,2-Dibromo-3-chloropropane	–	0.5
Isopropylbenzene	–	0.2	1,2-Dibromoethane	–	0.2
Methyl tert-butyl ether (MTBE)	–	0.2	1,2-Dichlorobenzene (ortho-)	600	0.1
n-Propylbenzene	–	0.2	1,2-Dichloroethane	5	0.2
Naphthalene	–	0.5	1,2-Dichloropropane	5	0.1
sec-Butylbenzene	–	0.2	1,3,5-Trimethylbenzene	–	0.2
Styrene	100	0.1	1,3-Dichlorobenzene	–	0.1
tert-Butylbenzene	–	0.2	1,3-Dichloropropane	–	0.2
Tetrachloroethylene	5	0.1	1,4-Dichlorobenzene (para-)	75	0.1
Tetrachloromethane (Carbon tet)	5	0.2	2,2-Dichloropropane	–	0.2
Toluene	1,000	0.2	2-Chlorotoluene	–	0.2
trans-1,2-Dichloroethylene	100	0.1	4-Chlorotoluene	–	0.2
trans-1,3-Dichloropropene	–	0.24	4-Isopropyl-1-methylbenzene	–	0.2
Tribromomethane (Bromoform)	*	0.2			

Performance Audits

Performance audits are conducted routinely at three levels: (1) at the field level, (2) at the laboratory level, and (3) through National Field Quality-Assurance Tests. At the field level, the Project Chief or a designee routinely accompanies the field personnel to a selected number of sites to ascertain whether proper field techniques are used to collect and preserve the samples; to ensure that proper safety procedures are followed; and, when necessary, to evaluate the training of new employees. The field auditor's checklist is shown in appendix 8. Written results of the field audits are provided to the employee, and copies of the field audits are stored in the office quality-assurance files on the server. Performance audits at the laboratory level are done in compliance with the process outlined in the individual laboratories quality assurance manuals or procedures.

The USGS INL Project Office participates in the National Field Quality-Assurance Program established by the USGS to evaluate the accuracy of water-quality field measurements. Quality-assurance blind samples are sent to field personnel for testing. The results are sent back to the water-quality service unit for evaluation. If field personnel or equipment do not pass the test, corrective action is taken. The program is described in detail by Erdmann and Thomas (1985).

In addition to the routine performance audits, water-quality activities at the INL Project Office are periodically monitored and reviewed by other USGS personnel: the Water-Quality Specialist for the USGS Idaho Water Science Center, Boise, Idaho; and personnel at the Office of Quality Assurance. Reviews by personnel at the USGS Idaho Water Science Center take place at 1–2-year intervals; reviews by the Office of Quality Assurance take place at 3–4-year intervals. The reviews are summarized in writing, and the reports are distributed to the USGS INL Project Office, Idaho Water Science Center and to the Office of Quality Assurance. If deficiencies are documented, the Chief of the USGS INL Project Office must submit a written reply outlining the necessary corrective action.

Corrective Actions

If the performance audits indicate inconsistencies or inadequacies in field methods or in analytical results by the laboratories, the problems are documented, and the field personnel or laboratories are notified in writing of the inconsistencies or inadequacies. Training is provided to the field personnel as needed, and the frequency of performance audits is increased until the performance is judged by the USGS INL Project Office Chief to be suitable and consistent with written guidelines.

Inconsistencies and inadequacies in laboratory analyses are discussed with or submitted in writing to the appropriate laboratory director, who is responsible for initiating the appropriate action to resolve the problem. To evaluate whether appropriate actions are taken, the frequency and numbers of replicate, blank, split, or other quality-assurance samples are increased until it is demonstrated that problems in the laboratory methods are resolved.

If USGS INL Project Office personnel discover a problem with sampling procedures, well integrity, equipment calibration, or data review analysis and interpretation that cannot be resolved at the project level, the USGS Idaho Water Science Center Water-Quality Specialist is notified of the problem. If the specialist cannot resolve the problem in consultation with the USGS Office of Quality Assurance, the problem may be referred to the USGS's research hydrologists and chemists who may be able to aid in resolving the problem.

Reporting of Data

All data collected by the USGS INL Project Office are publically available, after review, and most data are published in data reports and used in interpretive reports. Water-quality information, subsequent to its review, is entered into the NWIS and periodically merged with a nationally-accessible database. Data that suggest a possible human health or environmental problem are provided to managerial agencies such as the DOE and to regulatory agencies, such as the State of Idaho's Department of Environmental Quality and the USEPA, Region 10. After data have been reviewed and verified—by resampling if necessary—they are available to the general public either upon request or through the USGS National Water Information System Web portal at <https://waterdata.usgs.gov/nwis>.

Quality Assurance for Water-Level Measurements

Routine measurements are collected with a calibrated e-tape and are checked by taking two readings that need to be within ± 0.02 ft of each other. While in the field, the final measurement is compared to historic measurements to ensure the readings that are taken are reasonable. If the readings don't seem reasonable, a measurement is retaken. Well integrity for wells measured routinely are checked with downhole video and geophysical logs whenever pumps are pulled.

MLMS pressure measurements are checked at each site by taking a second pressure reading from two duplicate ports after all the first pressure readings have been taken from the ports. Historical pressure readings are reviewed in the field to assure probe location and accurate readings are collected.

Training Requirements and Site Safety

Training and site safety are important components of the USGS INL Project Office QAP. Employees are not assigned tasks for which they are not adequately trained, and all employees have a stop-work authority if they feel that work conditions are unsafe. The responsibility for ensuring that employees are adequately trained is shared jointly by the employee and the employee's supervisor. A more detailed description of USGS INL Project Office personnel training requirements and site safety requirements are given in the USGS INL Site Safety and Job Hazard Analysis Document (R. Bartholomay, USGS, December 2020, written commun.).

USGS INL Project Office personnel are called on from time to time to sample or measure wells for which no USGS-collected data are available. When this situation occurs, an effort will be made to ascertain if samples have been collected by other environmental monitoring programs to determine if there is any potential health risk to sample-collection personnel or laboratory-analysis personnel. To minimize the risk of contaminating low-level environmental laboratories, the laboratory analytical request form and the sample bottles will be noted as containing either samples with unknown or expected concentrations of contaminants that are potentially large.

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Appendix 1. Field Schedule Showing Well and Pump Information and Sampling Schedules for Selected Wells and Streamflow Sites

Table 1.1. Field schedule showing well and pump information and sampling schedules for selected wells and streamflow sites.

[**Abbreviations and symbols:** NRF, Naval Reactor Facility; gpm, gallon per minute; <, indicates the diameter is less than the hole depth indicated; >, indicates the diameter is greater than the hole depth indicated; –, not applicable]

Local site identifier	Method of sampling	Hole diameter (inches)	Well depth (feet)	Analysis type (see code)		Westbay Code; zone	NRF (see code)	
				April	October		May	November
ANP 6	Pump 25 gpm	10	295	–	5	–	–	–
ARA-MON-A-002	Pump 15 gpm	6	620	–	19	–	–	–
AREA 2	Pump 18 gpm	16	876	–	5	–	–	–
BLR (near Mackay)	Surface water	–	–	–	3	–	–	–
BLR (INEL Div.) ¹	Surface water	–	–	3	–	–	–	–
Birch Creek ¹	Surface water	–	–	–	1	–	–	–
CFA 1 ¹	Pump 1,000 gpm	16	639	10	–	–	–	–
CFA 2 ¹	Pump 1,400 gpm	16	681	–	10	–	–	–
CFA LF 2-10	Pump 8.3 gpm	6	716	20	–	–	–	–
CPP 1	Pump 3000 gpm	16	586	18	–	–	–	–
Cross Road ¹	Pump 35 gpm	8	796	19	–	–	–	–
CWP 1	Bail	6	58	4	–	–	–	–
CWP 8	Bail	6	63.5	4	–	–	–	–
GIN 2	Pump 2 gpm	2	381	–	24	–	–	–
Highway 3 ^{1,3}	Spigot	8	750	–	22	–	–	–
1ICPP-MON-A-166 ¹	Pump 20 gpm	6	527	14	–	–	–	–
ICPP-MON-V-200	Pump 4 gpm	6	127	–	14	–	–	–
Little Lost River	Surface water	–	–	–	1	–	–	–
MTR Test	Pump 26 gpm	8	588	8	–	–	–	–
Mud Lake ¹	Surface water	–	–	–	1	–	–	–
Middle 2050A ⁵	Multi-depth thief sampler	(6)	1,376	–	–	19; zone 15	–	–
Middle 2051 ^{1,5}	Multi-depth thief sampler	(6)	1,177	–	–	19; zones 3,9	–	–
No Name 1 (Tan Expl.)	Pump 42 gpm	12	550	24	–	–	–	–
NRF 3	Pump 28 gpm	16	546	–	–	–	32	34
NRF 6 ¹	Pump 30 gpm	8	417	–	–	–	32	34
NRF 7	Pump 2.5 gpm ⁴	10	417	–	–	–	31	33
NRF 8	Pump 30 gpm	8	423	–	–	–	32	34
NRF 9 ¹	Pump 30 gpm	8	422	–	–	–	32	34
NRF 10	Pump 30 gpm	8	427	–	–	–	32	34
NRF 11 ¹	Pump 30 gpm	8	417	–	–	–	32	34
NRF 12 ¹	Pump 30 gpm	8	421	–	–	–	32	34
NRF 14	Pump 25 gpm	10	550	–	–	–	32	34
NRF 16	Pump 25 gpm	5	422	–	–	–	32	34
NPR Test	Pump 28 gpm	6	600	–	19	–	–	–
PBF-MON-A-003	Pump 10 gpm	5	575	–	19	–	–	–
P and W 2 ¹	Pump 35 gpm	10	378	19	–	–	–	–
PW-8	Pump 8 gpm	6	166	13	–	–	–	–
PW-9 ¹	Bail	6	200	–	13	–	–	–
Rifle Range	Pump 25 gpm	5	620	–	14	–	–	–
RWMC M3S	Pump 6 gpm	6	633	–	17	–	–	–
RWMC M7S	Pump 6 gpm	6	628	–	17	–	–	–

Local site identifier	Method of sampling	Hole diameter (inches)	Well depth (feet)	Analysis type (see code)		Westbay Code; zone	NRF (see code)	
				April	October		May	November
RWMC M12S	Pump 6 gpm	6	572	—	19	—	—	—
RWMC M14S	Pump 6 gpm	6	635	—	19	—	—	—
RWMC Production ^{1,2}	Pump 200 gpm	10 <658 14 >658	685	—	17	—	—	—
Site 4	Pump 500 gpm	8	495	7	—	—	—	—
Site 6	Pump 30 gpm	10	523	—	—	—	32	34
Site 9	Pump 25 gpm	10	1,057	10	—	—	—	—
Site 17	Pump 25 gpm	15	600	5	—	—	32	34
SPERT 1	Pump 400 gpm	14	653	6	—	—	—	—
TAN 2271	Pump 1 gpm	10	282	—	24	—	—	—
TAN 2312	Pump 27 gpm	10	522	—	24	—	—	—
TRA 3	Pump 3,800 gpm	20	602	—	8	—	—	—
TRA Disp.	Pump 25 gpm	8 <1,114 6 >1,114	1267	—	14	—	—	—
W.S. for INEL-1	Pump 30 gpm	6	490	7	—	—	—	—
USGS 1	Pump 15 gpm	5	630	—	19	—	—	—
USGS 2	Pump 16 gpm	5	699	5	—	—	—	—
USGS 5	Pump 3 gpm ⁴	6	494	26	—	—	—	—
USGS 7	Pump 45 gpm	6 <760 4 >760	903	24	—	—	—	—
USGS 8 ¹	Pump 15 gpm	6	812	19	—	—	—	—
USGS 9	Pump 15 gpm	6	654	—	19	—	—	—
USGS 11 ^{1,3}	Pump 23 gpm	6	704	19	—	—	—	—
USGS 12	Pump 30 gpm	10	563	11	—	—	32	34
USGS 14 ^{1,3}	Pump 16 gpm	5	751	—	2	—	—	—
USGS 17	Pump 30 gpm	6 <365 5 >365	498	19	—	—	—	—
USGS 18 ¹	Pump 30 gpm	4	329	5	—	—	—	—
USGS 19 ¹	Pump 17 gpm	6	399	19	—	—	—	—
USGS 20	Pump 18 gpm	6	658	10	—	—	—	—
USGS 23	Pump 25 gpm	6 <430 5 >430	457	—	19	—	—	—
USGS 27 ¹	Pump 20 gpm ⁴	6	312	19	—	—	—	—
USGS 31	Pump 36 gpm	8 <306 10 >306	428	5	—	—	—	—
USGS 32	Pump 36 gpm	6 <324 5.5 >324	392	5	—	—	—	—
USGS 34	Pump 30 gpm	10	700	18	—	—	—	—
USGS 37	Pump 25 gpm	6	572	—	15	—	—	—
USGS 38	Pump 4 gpm ⁴	4	724	18	—	—	—	—
USGS 42	Pump 25 gpm	6	678	10	—	—	—	—
USGS 43	Pump 6 gpm	6	564	—	15	—	—	—
USGS 44	Pump 25 gpm	6	650	12	—	—	—	—
USGS 46	Pump 25 gpm	6	651	12	—	—	—	—
USGS 47	Pump 8 gpm	6	651	—	15	—	—	—
USGS 48	Pump 29 gpm	6	750	10	—	—	—	—
USGS 51	Pump 4 gpm	6	647	10	—	—	—	—
USGS 52	Pump 30 gpm	6	602	—	10	—	—	—
USGS 53	Bail	6	72	—	13	—	—	—
USGS 54	Pump 4 gpm	6	81	—	13	—	—	—
USGS 55 ¹	Pump 1 gpm	6	81	13	—	—	—	—
USGS 56	Bail	6	79	—	13	—	—	—
USGS 57	Pump 30 gpm	6	582	—	12	—	—	—

Local site identifier	Method of sampling	Hole diameter (inches)	Well depth (feet)	Analysis type (see code)		Westbay Code; zone	NRF (see code)	
				April	October		May	November
USGS 58	Pump 26 gpm	6	503	13	—	—	—	—
USGS 59	Pump 15 gpm	6	587	10	—	—	—	—
USGS 60	Pump 6 gpm	6	117	—	13	—	—	—
USGS 61	Pump 6 gpm	4	123	13	—	—	—	—
USGS 62	Pump 5 gpm	8	165	13	—	—	—	—
USGS 63	Pump 5 gpm	10	109	—	13	—	—	—
USGS 65 ¹	Pump 8 gpm	4	498	28	—	—	—	—
USGS 66 ¹	Bail	4	201	—	13	—	—	—
USGS 67	Pump 8 gpm	6 <465 4 >465	694	—	10	—	—	—
USGS 68 ¹	Pump 1 gpm ⁴	10	128	30	—	—	—	—
USGS 69	Pump 5 gpm	4	115	—	9	—	—	—
USGS 70 ¹	Pump 6 gpm	8	100	13	—	—	—	—
USGS 71	Bail	5	171	—	13	—	—	—
USGS 72	Bail	4	174	30	—	—	—	—
USGS 73 ¹	Bail	6	127	—	13	—	—	—
USGS 76	Pump 29 gpm	6	718	14	—	—	—	—
USGS 77	Pump 25 gpm	6	586	—	21	—	—	—
USGS 79	Pump 30 gpm	6	702	7	—	—	—	—
USGS 82	Pump 25 gpm	6	693	10	—	—	—	—
USGS 84	Pump 5 gpm	6	505	—	25	—	—	—
USGS 85 ¹	Pump 23 gpm	6	614	10	—	—	—	—
USGS 86	Pump 19 gpm	8	691	—	19	—	—	—
USGS 87 ¹	Pump 2 gpm	4	673	23	—	—	—	—
USGS 88	Pump 2 gpm	4	663	—	23	—	—	—
USGS 89	Pump 5 gpm	6	637	17	—	—	—	—
USGS 92	Bail	3.5	214	16	—	—	—	—
USGS 97	Pump 27 gpm	4	510	25	—	—	—	—
USGS 98	Pump 25 gpm	4	508	—	25	—	—	—
USGS 99	Pump 25 gpm	4	440	—	8	—	—	—
USGS 100 ¹	Pump 10 gpm ⁴	6	750	8	—	—	—	—
USGS 101	Pump 13 gpm	6 <750 4 >750	842	—	19	—	—	—
USGS 102	Pump 29 gpm	6	444	5	—	—	33	35
USGS 103 ^{1,5}	Multi-depth thief sampler	(6)	1,297	—	—	19; zones 1,3,6,9	—	—
USGS 104 ^{1,3}	Pump 26 gpm	8	700	—	6	—	—	—
USGS 105 ¹	Multi-depth thief sampler	(6)	1,300	—	—	19; zones 5,8,11	—	—
USGS 106	Pump 24 gpm	8	760	—	6	—	—	—
USGS 107	Pump 30 gpm	8	690	26	—	—	—	—
USGS 108 ^{1,5}	Multi-depth thief sampler	(6)	1,196	—	—	19; zones 1,9	—	—
USGS 110A	Pump 24 gpm	6	644	—	19	—	—	—
USGS 111	Pump 15 gpm ⁴	8	560	10	—	—	—	—
USGS 112 ^{1,3}	Pump 30 gpm	8	507	—	10	—	—	—
USGS 113	Pump 25 gpm	6	556	12	—	—	—	—
USGS 114 ³	Pump 10 gpm ⁴	6	560	—	10	—	—	—
USGS 115 ¹	Pump 5 gpm	6	581	—	10	—	—	—
USGS 116	Pump 20 gpm	6	572	10	—	—	—	—
USGS 117 ³	Pump 12 gpm ⁴	6.5	655	—	17	—	—	—
USGS 119 ³	Pump 2 gpm ⁴	6.5	705	17	—	—	—	—
USGS 120 ^{1,3}	Pump 27 gpm	6.5	705	—	23	—	—	—
USGS 123	Pump 3 gpm	6	514	—	10	—	—	—

Local site identifier	Method of sampling	Hole diameter (inches)	Well depth (feet)	Analysis type (see code)		Westbay Code; zone	NRF (see code)	
				April	October		May	November
USGS 124 ^{1,3}	Pump 15 gpm	4	800	6	—	—	—	—
USGS 127	Pump 25 gpm	6	596	20	—	—	—	—
USGS 128	Pump 23 gpm	4.5	615	—	18	—	—	—
USGS 130	Pump 25 gpm	4.5	636	—	19	—	—	—
USGS 131A ⁵	Multi-depth thief sampler	(6)	1,198	—	—	19; zones 8, 12	—	—
USGS 132 ^{1,5}	Multi-depth thief sampler	(6)	1,238	—	—	19; zone 14	—	—
USGS 133 ⁵	Multi-depth thief sampler	(6)	798	—	—	19; zone 10	—	—
USGS 136	Pump 21 gpm	6	560	—	14	—	—	—
USGS 137A ¹	Multi-depth thief sampler	(6)	1,317	—	—	19; zones 4, 5	—	—
USGS 140	Pump 24 gpm	6	546	—	14	—	—	—
USGS 143	Pump 18 gpm	6	801	19	—	—	—	—
USGS 144	Pump 18 gpm	6	627	19	—	—	—	—
USGS 146	Pump 20 gpm	6	800	—	19	—	—	—
USGS 147	Pump 13 gpm	8	729	19	—	—	—	—
USGS 148A ¹	Pump 16 gpm	4	759	—	19	—	—	—
USGS 149 ⁵	Multi-depth thief sampler	(6)	970	—	—	19; all 4 zones	—	—

¹Well is sampled with someone from the State of Idaho's Idaho National Laboratory Oversight Program

²Well is sampled monthly for organics (sample code 27) - SH1380

³Well is sampled with someone from Shoshone/Bannock Tribe

⁴Indicates well needs to be cut back to pump rate indicated; all other pump rates are approximate.

⁵Site sample schedules for the multi-depth sampler are subject to change from year to year; code 29 after installation; routinely will sample for code 19 at select zones.

⁶Hole diameter is not required for bore hole volume calculations with Multi-depth thief samplers.

Codes for Types of Analyses (Number of Bottles Needed in Parenthesis)

1. ³H, Cl⁻ (2)
2. ³H, α, β, Cl⁻, Na⁺, NO³⁻ (5)
3. ³H, Cl⁻, α, β, (3)
4. ³H, ⁹⁰Sr, Cl⁻, Cr, SO⁴⁻⁻ (4)
5. ³H, Cl⁻, Na⁺, NO³⁻, SO⁴⁻⁻ (4)
6. ³H, Cl⁻, Na⁺, NO³⁻ (4)
7. ³H, Cl⁻, Cr, Na⁺, SO⁴⁻⁻ (3)
8. ³H, Cl⁻, Cr, Na⁺, NO³⁻, SO⁴⁻⁻ (4)
9. ³H, ⁹⁰Sr, Y Spec, Cl⁻, Na⁺, SO⁴⁻⁻ (4)
10. ³H, ⁹⁰Sr, Cl⁻, Na⁺, NO³⁻, SO⁴⁻⁻ (5)
11. ³H, α, β, Y Spec, Cl⁻, Na⁺ (5)
12. ³H, ⁹⁰Sr, Y Spec, Cl⁻, Na⁺, NO³⁻, SO⁴⁻⁻ (5)
13. ³H, ⁹⁰Sr, Y Spec, Cl⁻, Cr, Na⁺, SO⁴⁻⁻ (4)
14. ³H, ⁹⁰Sr, Y Spec, Cl⁻, Cr, Na⁺, NO³⁻, SO⁴⁻⁻ (5)
15. ³H, ⁹⁰Sr, Y Spec, ²⁴¹Am, ²³⁸Pu, ^{239,240}Pu, Cl⁻, Na⁺, NO³⁻, SO⁴⁻⁻ (5)
16. ³H, ⁹⁰Sr, Y Spec, ²⁴¹Am, ²³⁸Pu, ^{239,240}Pu, Cl⁻, VOC's (6)
17. ³H, Cl⁻, Cr, Na⁺, NO³⁻, VOCs, SO⁴⁻⁻ (7)
18. ³H, α, β, Cl⁻, Na⁺, Cr, NO³⁻, SO⁴⁻⁻, F⁻, VOCs, (8)
19. ³H, α, β, Cl⁻, Na⁺, Cr, SO⁴⁻⁻, NO³⁻ (5)
20. ³H, ⁹⁰Sr, α, β, Y Spec, Cl⁻, Na⁺, Cr, NO³⁻, (6)
21. ³H, ⁹⁰Sr, α, β, Y Spec, ²⁴¹Am, ²³⁸Pu, ^{239,240}Pu, Cl⁻, Na⁺, Cr, NO³⁻, F⁻, SO⁴⁻⁻ VOCs, (9)

22. ^3H , α , β , Cl^- , Na^+ , Cr , NO_3^- , SO_4^{4-} , VOC's, (8)
23. ^3H , ^{90}Sr , α , β , γ Spec, ^{241}Am , ^{238}Pu , $^{239,240}\text{Pu}$, Cl^- , Na^+ , Cr , NO_3^- , SO_4^{4-} VOCs, (9)
24. ^3H , ^{90}Sr , α , β , γ Spec, Cl^- , Na^+ , NO_3^- , VOCs, Hg, metals (SH 1050) + As, Tl (12)
25. ^3H , α , β , Cl^- , Na^+ , NO_3^- , SO_4^{4-} , VOCs, Hg, metals (SH 1050) + As, Se (10)
26. ^3H , α , β , Cl^- , Na^+ , Cr , NO_3^- , (5)
27. VOCs (3)
28. ^3H , ^{90}Sr , α , β , γ Spec, ^{241}Am , ^{238}Pu , $^{239,240}\text{Pu}$, Cl^- , Na^+ , NO_3^- , SO_4^{4-} , VOCs, Hg, metals (SH 1050) + As, Se (12)
29. New well: Alkalinity, ^3H , ^{90}Sr , α , β , γ Spec, ^{241}Am , ^{238}Pu , $^{239,240}\text{Pu}$, NO_3^- , VOCs, Hg, anions (SH 670), metals and cations (SH 2126) + B, U-isotopes, H^2/O^{18} (13)
30. ^3H , ^{90}Sr , α , β , γ Spec, Cl^- , Na^+ , SO_4^{4-} , metals (SH 1281) (7)
31. NRF ^3H , ^{90}Sr , ^{63}Ni , γ Spec, raw metals, raw and filtered nutrients, anions, VOCs, Semi-vols, pH/TDS, (14)
32. NRF ^3H , ^{90}Sr , ^{63}Ni , γ Spec, raw and filtered metals, raw and filtered nutrients, anions, VOCs, Semi-vols, pH/TDS, (15)
33. NRF ^3H , ^{90}Sr , ^{63}Ni , γ Spec, raw metals, raw and filtered nutrients, anions, pH/TDS, (9)
34. NRF ^3H , ^{90}Sr , ^{63}Ni , γ Spec, raw and filtered metals, raw and filtered nutrients, anions, pH/TDS, (10)

Table 1.2. Constituent and type of sample.

[Abbreviations: mL, milliliter]

Type of analyses	Lab	Size of sample and schedule or lab code	Type of sample treatment
^3H (Ru)	RESL	500 mL (Apr, Oct)	Raw water, unacidified, rinse bottle
^{90}Sr (RA)	RESL	500 mL	Raw water, preserved with 2 mL HNO_3 , no rinse
^{90}Sr , γ Spec (RA)	RESL	500 mL	Raw water, preserved with 2 mL HNO_3 , no rinse
α , β (RA)	RESL	500 mL	Raw water, preserved with 2 mL HNO_3 , no rinse
^{241}Am , ^{238}Pu , $^{239,240}\text{Pu}$ (RA)	RESL	500 mL	Raw water, preserved with 2 mL HNO_3 , no rinse
^{90}Sr , γ Spec, ^{241}Am , ^{238}Pu , $^{239,240}\text{Pu}$ (RA)	RESL	1 L	Raw water, preserved with 4 mL HNO_3 , no rinse
γ Spec (RA)	RESL	500 mL	Raw water, preserved with 2 mL HNO_3 , no rinse
F^{--} (FU)	NWQL	250 mL; LC 651	Filtered, unacidified, rinse poly bottle
Na^{+} (FA)	NWQL	250 mL; LC 675	Filtered, preserved with 2 mL Ultrex HNO_3 , rinse poly bottle
Cr^* (FA)	NWQL	250 mL; LC 722	Filtered, preserved with 2mL Ultrex HNO_3 , rinse poly bottle
Cl^{--} (FU)	NWQL	250 mL; LC 1571	Filtered, unacidified, rinse poly bottle
SO_4^{4-} (FU)	NWQL	250 mL; LC 1572	Filtered, unacidified, rinse poly bottle
Hg (FAM)	NWQL	250 mL; LC 2707	Filtered, preserved with 2 mL 6N HCL, rinse, clear glass bottle
Carbon-13/carbon-12 (FUS)	RSIL	1L, LC 1851	Filtered, unacidified, plastic coated glass bottle fitted with polyseal cone cap, chill, provide alkalinity & pH
NO_3^- (FCC)	NWQL	125 mL; SH101	Filtered, chilled, brown poly bottle, rinse bottle
SH 670 anions (FU)	NWQL	250 mL; SH 670	Filtered, unacidified, rinse poly bottle
Sp. Cond. (RU)		250 mL; SH 670	Raw water, unacidified, rinse poly bottle
SH 1050 metals (FA)	NWQL	250 mL; SH 1050 and LC 3122 and 2508	Filtered, preserved with 2 mL ultrex HNO_3 , rinse poly bottle
As, Tl (FA)			
Sp. Cond. (RU)		250 mL; SH 1050	Raw water, unacidified, rinse poly bottle

Type of analyses	Lab	Size of sample and schedule or lab code	Type of sample treatment
SH 1050 metals (FA)	NWQL	250 mL; SH 1050 and	Filtered, preserved with 2 mL Ultrex HNO ₃ , rinse
As, Se (FA)		LC 3122 and 3132	poly bottle
Sp. Cond. (RU)		250 mL; SH 1050	Raw water, unacidified, rinse, poly bottle
Uranium 234, 235, 238	Test	1L; SH 1130	Filtered, acidified with 4 mL Ultrex HNO ₃ , rinse
isotopes (FAR)	America		poly bottle
Oxygen/deuterium	RSIL	60 mL; SH 1142	Raw water, unacidified, no rinse
isotopes (RUS)			
VOCs (GCV)	NWQL	(3) 40 mL; SH1380	Raw water, chilled, unacidified, rinse glass bottle, amber
SH 1281 TCLP metals	NWQL	250 mL; SH 1281	Raw, preserved with 2 mL Ultrex HNO ₃ , rinse poly
(RA)		250 mL; SH 1281	bottle
Hg (RAM)			Raw water, preserved with 2 ml 6N HCl, rinse clear glass bottle
SH 2126 metals & cations	NWQL	250 mL; SH 2126	Filtered, preserved with 2 ml Ultrex HNO ₃ , rinse
(FA)		and LC 2110	poly bottle
B (FA)		250 mL; SH 2126	Raw water, unacidified, rinse poly bottle
Sp. Cond. and pH (RU)			
¹²⁹ I	PRIME	1L	Filtered, unacidified, rinse, polyseal cap, no head space, amber glass or poly

*Analysis can be requested from the same bottle.

**Analysis can be requested from the same bottle.

Appendix 2. Water-Level Measurement Schedule.

Table 2.1. Water-level measurement schedule.

[**Abbreviations:** Jan, January; Feb, February; Mar, March; Apr, April; Jun, June; Jul, July; Aug, August; Sep, September; Oct, October; A, aquifer; AM, aquifer measured monthly; AA, aquifer well measured annually; ANRF, aquifer well measured for NRF; AS, aquifer well measured semi-annually; AQ, aquifer well measured quarterly; PA, perched well measured annually; PM, perched well measured monthly; PS, perched well measured semi-annually; PQ, perched well measured quarterly; R, well equipped with continuous water-level recorder; RT, continuous recorded real-time; S, water sample and water level collected]

WELL NAME	Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
USGS 1	A		RT			RT			RT		S	RT	
USGS 2	A	AQ			S			AQ			AQ		
USGS 4	A		R			R			R			R	
USGS 5	A	AQ			S			AQ			AQ		
USGS 6	A	AQ		AQ				AQ			AQ		
USGS 7	A	AQ			S			AQ			AQ		
USGS 8	A	AQ			S			AQ			AQ		
USGS 9	A		R			R			R		S	R	
USGS 11	A	AQ			S			AQ			AQ		
USGS 12	A		R		S	R & S			R			S	
USGS 13	A				AA								
USGS 14	A	AQ			AQ			AQ			S		
USGS 15	A	AQ			AQ			AQ			AQ		
USGS 17	A	AQ			S			AQ			AQ		
USGS 18	A	AQ			S			AQ			AQ		
USGS 19	A	AM	AM	AM	S	AM	AM	AM	AM	AM	AM	AM	AM
USGS 20	A	AQ			S			AQ			AQ		
USGS 21	A		RT			RT			RT			RT	
USGS 22	A	AQ			AQ			AQ			AQ		
USGS 23	A	AQ			AQ			AQ			S		
USGS 24	A		R			R			R			R	
USGS 25	A		R			R			R			R	
USGS 26	A	AQ			AQ			AQ			AQ		
USGS 27	A	AM	AM	AM	S	AM	AM	AM	AM	AM	AM	AM	AM
USGS 28	A			AS						AS			
USGS 29	A			AS							AS		
USGS 30A	A			AQ			AQ			AQ			AQ
USGS 30C	A			AQ			AQ			AQ			AQ

WELL NAME	Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
USGS 31	A				S						AS		
USGS 32	A				S						AS		
USGS 34	A				S								
USGS 37	A										S		
USGS 38	A				S								
USGS 39	A	AQ		AQ				AQ			AQ		
USGS 42	A				S								
USGS 43	A										S		
USGS 44	A				S								
USGS 46	A				S								
USGS 47 No wl sample only	A										S		
USGS 48	A				S						AS		
USGS 51	A				S								
USGS 52	A										S		
USGS 53 (6 to 4 inch @30ft)	P				PS						S		
USGS 54	P	PQ		PQ				PQ			S		
USGS 55	P	PQ			S			PQ			PQ		
USGS 56	P										S		
USGS 57	A	AQ			AQ			AQ			S		
USGS 58	A				S								
USGS 59	A				S						AQ		
USGS 60	P	PQ			PQ			PQ			S		
USGS 61	P	PQ			S			PQ			PQ		
USGS 62	P	PQ			S			PQ			PQ		
USGS 63	P	PQ			PQ			PQ			S		
USGS 65	A	AQ			S			AQ			AQ		
USGS 66	P	PQ			PQ			PQ			S		
USGS 67	A			AS							S		
USGS 68	P	PQ			S			PQ			PQ		
USGS 69	P	PQ			PQ			PQ			S		
USGS 70	P	PQ			S			PQ			PQ		
USGS 71	P	PQ			PQ			PQ			S		
USGS 72	P	PQ			S			PQ			PQ		
USGS 73	P	PQ			PQ			PQ			S		
USGS 76	A				S								
USGS 77	A										S		
USGS 78	P	PM	PM	PM	PM	PM	PM	PM	PM	PM	S	PM	PM
USGS 79	A				S						AS		

WELL NAME	Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
USGS 82	A	AQ			S			AQ			AQ		
USGS 83	A	AQ			AQ			AQ			AQ		
USGS 84	A	AQ			AQ			AQ			S		
USGS 85	A	AQ			S			AQ			AQ		
USGS 86	A	AQ			AQ			AQ			S		
USGS 87	A				S								
USGS 88	A										S		
USGS 89	A	AQ			S			AQ			AQ		
USGS 92	P	PQ			S			PQ			PQ		
USGS 97	A	AM	AM	AM	S	ANRF	AM	AM	AM	AM	AM	ANRF	AM
USGS 98	A					ANRF					S	ANRF	
USGS 99	A					ANRF					S	ANRF	
USGS 100	A	AQ			S			AQ			AQ		
USGS 101	A	AQ			AQ			AQ			S		
USGS 102	A				S	S						S	
USGS 104	A	AQ			AQ			AQ			S		
USGS 106	A			AS							S		
USGS 107	A				S						AS		
USGS 109	A				AA								
USGS 110A	A				AS						S		
USGS 111	A				S								
USGS 112	A			AS							S		
USGS 113	A				S								
USGS 114	A										S		
USGS 115	A										S		
USGS 116	A	AQ			S			AQ			AQ		
USGS 117	A				AS						S		
USGS 119	A				S								
USGS 120	A	AM	AM	AM	AM	AM	AM	AM	AM	AM	S	AM	AM
USGS 121	A				AA								
USGS 123	A										S		
USGS 124	A				S						AS		
USGS 125	A	AQ			AQ			AQ			AQ		
USGS 126B	A	AQ			AQ			AQ			AQ		
USGS 127	A	AQ			S			AQ			AQ		
USGS 128	A			AS							S		
USGS 129	A			AQ			AQ			AQ			AQ
USGS 130	A	AQ			AQ			AQ			S		

WELL NAME	Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
USGS 131	A				AA								
USGS 136	A										S		
USGS 138	A		R			R			R			R	
USGS 139A	A	AQ			AQ			AQ			AQ		
USGS 139B	A	AQ			AQ			AQ			AQ		
USGS 140	A										S		
USGS 142	A	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM
USGS 142A	A	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM
USGS 143	A	AQ			S			AQ			AQ		
USGS 144	A				S								
USGS 145A	A	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM
USGS 145B	A	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM
USGS 146	A				AS						S		
USGS 147	A	AM	AM	AM	S	AM	AM	AM	AM	AM	AM	AM	AM
USGS 148A	A	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM
A11A31	A			AA									
ANL MON A 014	A			AA									
ANP 5	A				AA								
ANP 6	A				AS						S		
ANP 7	A				AA								
ANP 9	A	AQ			AQ			AQ			AQ		
ANP 10	A				AA								
ARA-MON-A-002	A	AQ			AQ			AQ			S		
ARBOR TEST	A	AQ			AQ			AQ			AQ		
AREA 2	A				AS						S		
CERRO GRANDE	A			AA									
CFA 1932	A			AS							AS		
CFA LF 2-10	A	AQ			S			AQ			AQ		
CFA LF 2-11	A			AA									
COREHOLE 1	A	AQ		AQ				AQ			AQ		
COREHOLE 2A	A	AQ			AQ			AQ			AQ		
CWP 1	P				S								
CWP 2	P				PA								
CWP 3	P				PA								
CWP 4	P				PA								
CWP 5	P				PA								
CWP 6	P				PA								
CWP 7	P				PA								

WELL NAME	Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CWP 8	P				S								
CWP 9	P				PA								
DH 1B	A			AQ			AQ			AQ			AQ
DH 2A	A			AQ			AQ			AQ			AQ
FIRE STATION 2	A			AQ			AQ			AQ			AQ
GIN 2 No wl sample only	A										S		
GIN 3	A			AA									
HWY 1A PIEZO 3	A			AQ			AQ			AQ			AQ
HWY 1B PIEZO 2	A			AQ			AQ			AQ			AQ
HWY 1C PIEZO 1	A			AQ			AQ			AQ			AQ
HWY 2	A			AQ			AQ			AQ			AQ
ICPP-MON-A-166	A	AQ			S			AQ			AQ		
ICPP-MON-V-200	P	PQ			PQ			PQ			S		
INEL 1	A			AA									
MTR TEST	A	AM	AM	AM	S	AM	AM	AM	AM	AM	AM	AM	AM
NO NAME 1	A	AQ			S			AQ			AQ		
NPR TEST	A	AQ			AQ			AQ			S		
NRF 2	A					ANRF						ANRF	
NRF 3	A					S						S	
NRF 5	A					ANRF						ANRF	
NRF 6	A					S						S	
NRF 7	A					S						S	
NRF 8	A					S						S	
NRF 9	A					S						S	
NRF 10	A					S						S	
NRF 11	A					S						S	
NRF 12	A					S						S	
NRF 13	A					ANRF						ANRF	
NRF 14	A					S						S	
NRF 15-A	A	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM
NRF 15-B	A	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM
NRF 16	A					S						S	
PandW 1	A				AA								
PandW 2	A				S						AS		
PandW 3	A				AA								
PBF-MON-A-003	A			AS							S		
PSTF TEST	A				AS						AS		
PW 8	P	PQ			S			PQ			PQ		

WELL NAME	Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PW 9	P	PQ			PQ			PQ			S		
RWMC M3S	A				AS						S		
RWMC M6S	A				AA								
RWMC M7S	A				AS						S		
RWMC M12S	A				AS						S		
RWMC M14S	A				AS						S		
SITE 6	A					S						S	
SITE 9	A	AQ			S			AQ			AQ		
SITE 14	A	AQ			AQ			AQ			S		
SITE 15	A				AA								
SITE 17	A		R		S	S			R			S	
SITE 19	A			AS							AS		
TAN CH 2 piezo B	A			AQ			AQ			AQ			AQ
TAN 14	A			AS						AS			
TAN 15	A			AS						AS			
TAN 17	A			AQ			AQ			AQ			AQ
TAN 2271 No wl sample only	A										S		
TAN 2312	A				AS						S		
TRA DISP	A										S		
WS INEL 1	A				S						AS		
04N 35E 31DAA1	A				AA								
02N 26E 22DDA1	A				AA								
02N 26E 22DDA2	A				AA								
RMS entry needed													
Monthly totals		79	23	47	132	39	26	76	23	29	124	40	26
Sampled wells		0	0	0	60	14	0	0	0	0	57	14	0
W/L's only		79	23	47	72	25	26	76	23	29	67	26	26
TOTAL PERCHED	29												
TOTAL AQUIFER	174												
TOTAL WELLS	203												

Appendix 3. Data-Quality Objectives for Routine Water Samples Analyzed by the National Water Quality Laboratory

Table 3.1. Data-quality objectives for routine water samples analyzed by the National Water Quality Laboratory.

[**Accuracy:** Coefficient of variance measured by replicate analysis. **Abbreviations:** N, nitrogen; P, phosphorus; µg/L, micrograms per liter]

Constituent	Reporting level (µg/L)	Precision (+/- percent)	Accuracy (percent)	Lab code/schedule
I. Volatile organic compounds	Variable	30	70–130	SH 1380
II. Inorganic compounds (filtered):				
Aluminum	3.0	10	90–110	SH 1050
Antimony	0.06	10	90–110	SH 1050
Arsenic	0.1	10	90–110	LC 3122
Barium	0.6	10	90–110	SH 1050
Beryllium	0.01	10	90–110	SH 1050
Boron	2.0	10	90–110	LC 2110
Bromide	10	10	90–110	SH 670
Cadmium	0.03	10	90–110	SH 1050
Calcium	22	10	90–110	SH 2126
Chloride	20	10	90–110	LC 1571
Chromium	0.6	10	90–110	LC 722
Cobalt	0.03	10	90–110	SH 1050
Copper	0.4	10	90–110	SH 1050
Fluoride	10	10	90–110	LC 651
Iron	10	10	90–110	SH 2126
Lead	0.02	10	90–110	SH 1050
Lithium	0.15	10	90–110	SH 2126
Magnesium	0.01	10	90–110	SH 2126
Manganese	0.40	10	90–110	SH 1050
Mercury	0.005	10	90–110	LC 2707
Molybdenum	0.05	10	90–110	SH 1050
Nickel	0.20	10	90–110	SH 1050
Potassium	300	10	90–110	SH 2126
Selenium	0.05	10	90–110	LC 3132
Silica	50	10	90–110	SH 2126
Silver	1.0	10	90–110	SH 1050
Sodium	200	10	90–110	LC 675
Strontium	0.5	10	90–110	SH 2126
Sulfate	20	10	90–110	LC 1572
Thallium	0.04	10	90–110	LC 2508
Tungsten	0.03	10	90–110	SH 2126
Uranium	0.03	10	90–110	SH 1050
Vanadium	0.1	10	90–110	SH 2126
Zinc	2.0	10	90–110	SH 1050
Ammonia (as N)	10	40	60–140	SH 101
Nitrite (as N)	1.0	10	90–110	SH 101
Nitrite + Nitrate (as N)	40	10	90–110	SH 101
Orthophosphate (as P)	4.0	10	90–110	SH 101

Appendix 4. Data-Quality Objectives for Radionuclides in Water Samples Analyzed by the Radiological and Environmental Sciences Laboratory

For each radionuclide concentration, an associated analytical uncertainty (s) is calculated such that there is a 67-percent probability that the true concentration of a radionuclide in a sample is in the range of the reported concentration plus or minus the analytical uncertainty. For example, given an analytical result of 1.0 ± 0.2 pCi/L (picocuries per liter), there is a 67-percent probability that the true concentration is in the range of 0.8 to 1.2 pCi/L. Some laboratories report the analytical uncertainty as $2s$, at which there is a 95-percent probability that the true concentration is in the range of 0.6–1.4 pCi/L. Therefore, unlike analyses for most inorganic or organic constituents, the analytical uncertainty is specified for each analysis for a specified radionuclide. The following guidelines for interpreting analytical results are based on an extension of the method described by Currie (1968).

In the analysis for a selected radionuclide, laboratory measurements are made on a target sample and a prepared blank. Instrument signals for the sample and the blank vary randomly. Therefore, it is essential to distinguish between two key aspects of the problem of detection: (1) the instrument signal for the sample must be greater than the signal observed for the blank to make the decision that a selected radionuclide was detected; and (2) an estimation must be made of the minimum radionuclide concentration that will yield a sufficiently large observed signal to make the correct decision of detection or nondetection of that radionuclide most of the time. The first aspect of the problem is a qualitative decision based on an observed signal and a definite criterion for detection. The second aspect of the problem is an intuitive estimation of the detection capabilities of a given measurement process.

In the laboratory, instrument signals must exceed a critical level to make the qualitative decision whether a selected radionuclide was detected. Radionuclide concentrations that equal $1.6s$ meet this criterion; at $1.6s$, there is a 95-percent probability that the correct decision—not detected—will be made. Given a large number of samples, up to 5 percent of the samples with true concentrations greater than or equal to $1.6s$, which were concluded as being detected, might not contain the selected radionuclide. These measurements are referred to as false positives and are errors of the first kind in hypothesis testing.

Once the critical level of $1.6s$ has been defined, the minimum detectable concentration may be established. Radionuclide concentrations that equal $3s$ represent a measurement of the minimum detectable concentration. For true concentrations of $3s$ or greater, there is a 95-percent-or-more probability of correctly concluding that a selected radionuclide was detected in a sample. Given a large number of samples, up to 5 percent of the samples with true concentrations greater than or equal to $3s$, which were concluded as being nondetected, could contain the selected radionuclide at the minimum detectable concentration. These measurements are referred to as false negatives and are errors of the second kind in hypothesis testing. Inclusion of the $3s$ criterion reduces the probability of a false negative to 5 percent or less.

True radionuclide concentrations between $1.6s$ and $3s$ have larger errors of the second kind. That is, there is a greater-than-5-percent probability of false negative results for samples with true concentrations between $1.6s$ and $3s$, and although the selected radionuclide might not have been detected, such nondetection may not be reliable; at $1.6s$, the probability of false negative is about 50 percent.

These guidelines are based on counting statistics alone and do not include systematic or random errors inherent in laboratory procedures. The values $1.6s$ and $3s$ vary slightly with

background or blank counts and with the number of gross counts for individual analyses and for different selected radionuclides. The use of the critical level and minimum detectable concentration aid in the interpretation of analytical results and do not represent absolute concentrations of radioactivity which may or may not have been detected. The minimum detectable concentration should not be confused with the detection limit, which is based on instrument sensitivity, sample volumes, analytical procedures and counting times used in the laboratory.

Bodnar and Percival (1982) summarized detection limits normally available from the Radiological and Environmental Sciences Laboratory. Special arrangements can be made to achieve smaller detection limits for selected constituents. For example, by using a 5-fold counting time for tritium in water, that is, increasing the counting time from 20 to 100 minutes, the detection limit can be reduced from 500 to 200 pCi/L.

Detection limits for selected types of radioactivity and nuclides as a function of sample size and detection method are shown on table 4.1; the limits are intended as guides to order-of-magnitude sensitivities and, in practice, can easily change by a factor of two or more even for the conditions specified.

Table 4.1. Data-quality objectives for radionuclides in water samples analyzed by the Radiological and Environmental Sciences Laboratory.

[**Data source:** Guy Backstrom, U.S. Department of Energy, written commun., 2020. **Abbreviations:** bkgd, background; HPGe, high purity Germanium radiation detector]

Type of radioactivity or nuclide	Sample material	Size of sample (milliliter)	Counting time (minutes)	Detection method or instrument	Detection limit (picocuries per milliliter)
Gross alpha	Water	250	100	Low bkgd counter	3×10^{-3}
Gross beta	Water	250	100	Low bkgd counter	2×10^{-3}
Strontium-90	Water	400	200	Liquid scintillation	2×10^{-3}
Tritium	Water	10	100	Liquid scintillation	0.2
Thorium-230	Water	500	1,000	Alpha spectrometry	5×10^{-5}
Uranium-234	Water	500	1,000	Alpha spectrometry	5×10^{-5}
Plutonium-238 + Plutonium-239/240	Water	500	1,000	Alpha spectrometry	5×10^{-5}
Americium-241	Water	500	1,000	Alpha spectrometry	5×10^{-5}
Technicium-99	Water	400	100	Liquid scintillation	8×10^{-3}
Tellurium-132	Water	400	60	HPGe	6×10^{-2}
Selenium-75	Water	400	60	HPGe	0.8×10^{-2}
Antimony-125	Water	400	60	HPGe	0.2
Ruthenium-103	Water	400	60	HPGe	1×10^{-2}
Thallium-108	Water	400	60	HPGe	0.2
Antimony-124	Water	400	60	HPGe	0.1
Cobalt-60	Water	400	60	HPGe	6×10^{-2}
Potassium-40	Water	400	60	HPGe	1.0
Cerium-144	Water	400	60	HPGe	0.4
Cerium-141	Water	400	60	HPGe	9×10^{-2}
Chromium-51	Water	400	60	HPGe	0.6
Iodine-131	Water	400	60	HPGe	6×10^{-2}
Barium-140	Water	400	60	HPGe	0.2
Ruthenium-106	Water	400	60	HPGe	0.5
Cesium-137	Water	400	60	HPGe	6×10^{-2}
Cesium-134	Water	400	60	HPGe	6×10^{-2}
Molybdenum-99	Water	400	60	HPGe	5×10^{-2}

Type of radioactivity or nuclide	Sample material	Size of sample (milliliter)	Counting time (minutes)	Detection method or instrument	Detection limit (picocuries per milliliter)
Mercury-203	Water	400	60	HPGe	6×10^{-2}
Krypton-85	Water	400	60	HPGe	21
Zirconium-95	Water	400	60	HPGe	9×10^{-2}
Cobalt-58	Water	400	60	HPGe	6×10^{-2}
Manganese-54	Water	400	60	HPGe	5×10^{-2}
Silver-110	Water	400	60	HPGe	7×10^{-2}
Actinium-228	Water	400	60	HPGe	0.2
Iron-59	Water	400	60	HPGe	0.1
Zinc-65	Water	400	60	HPGe	0.1

Appendix 5. Data-Quality Objectives for Water Samples Analyzed by GEL Laboratories, LLC, TestAmerica Laboratories, and ARS International, LLC

The EPA (1994) has established six primary analytical data-quality objectives for environmental studies. These objectives are precision, accuracy, representativeness, completeness, comparability, and detectability. GEL Laboratories, LLC approach to each data quality objective is given in a report by GEL Laboratories, LLC (2015). TestAmerica Laboratories' (TAL) approach to each data-quality objective is given in a report by TestAmerica (2013, revision 5). The method of analyses, minimum reporting levels, and method detection limits for constituents analyzed by GEL, TAL and for tritium analysis done at the ARS International, LLC for the U.S. Geological Survey Idaho National Laboratory Project Office are given in table 5.1.

Table 5.1. Methods for analyses, minimum reporting levels, and method detection limits for constituents analyzed by the GEL Laboratories, LLC, and ARS International, LLC.

[**Abbreviations:** N, nitrogen; pCi/L, picocuries per liter; µg/L, micrograms per liter; –, not applicable. Tritium analyses were done by ARS International, LLC.]

Constituent	Method for analyses	Reporting level (µg/L)	Method detection limit (µg/L)
Volatile organic compounds	524.2	Variable	Variable
Semi-volatile organic compounds	525.2	Variable	Variable
Inorganic compounds			
Aluminum	3010A/6020A	50.0	19.3
Antimony	3010A/6020A	3.00	1.00
Arsenic	3010A/6020A	5.00	2.00
Barium	3010A/6020A	2.00	0.670
Beryllium	3010A/6020A	0.5	0.2
Cadmium	3010A/6020A	1.00	0.300
Calcium	3010A/6020A	2,000	800
Chloride	300.0	1,000	335
Chromium	6020	10.0	3.0
Copper	3010A/6020A	1.00	0.300
Iron	3010A/6020A	100	33.0
Lead	3010A/6020A	2.00	0.500
Magnesium	3010A/6020A	30.0	10.0
Manganese	3010A/6020A	5.00	1.00
Mercury	7470A	0.200	0.0670
Nickel	3010A/6020A	2.00	0.600
Potassium	3010A/6020A	300	80.0
Selenium	3010A/6020A	5.00	2.00
Silver	3010A/6020A	1.00	0.300
Sodium	3010A/6010A	250	80.0
Sulfate	300.0	2,000	665
Thallium	3010A/6020A	2.00	0.600
Zinc	3010A/6020A	10.0	3.3
Nitrite (as N)	300.0	100	33.0
Nitrate/Nitrite (as N)	353.2	100	35.0
Radionuclides			
Tritium	Liquid scintillation	3 pCi/L	–
Gamma	901.1	5 pCi/L	–

Constituent	Method for analyses	Reporting level (µg/L)	Method detection limit (µg/L)
Cobalt-60	901.1	5 pCi/L	—
Nickel-63	DOE RESL Ni-1, Mod	5 pCi/L	—
Strontium-90	905.0 Mod	1 pCi/L	—

Appendix 6. Data-Quality Objectives for Quality Control Data

Data-quality objectives for quality control data are presented as criteria for acceptable variability (measured as reproducibility and reliability from replicates) and contamination bias (measured from blanks) (Rattray, 2012, 2014).

The reproducibility for a constituent is considered acceptable if:

1. The normalized absolute difference of radiochemical constituents from a replicate is less than or equal to 1.96,
2. The relative standard deviation of inorganic and organic constituents from a replicate is less than 14 percent (this corresponds to a relative percent difference of less than 20 percent),
3. Both replicate measurements of a constituent are censored and (or) estimated because they are less than the reporting level for that analysis, or
4. One replicate measurement of a constituent is censored or estimated and the other replicate measurement of the constituent is within one detection limit of the larger of the estimated value or the reporting level, or the replicate measurements of a constituent are within one detection limit of each other.

If the percentage of replicates with acceptable reproducibility for a constituent is greater than or equal to 90 percent, then the reproducibility for that constituent is considered acceptable. If the percentage is less than 90 percent for a constituent, then the results for that constituent are investigated.

The reliability for a constituent is considered acceptable if the pooled relative standard deviation for that constituent is less than 14 percent. If the pooled relative standard deviation is greater than or equal to 14 percent for a constituent, then the results for that constituent will be investigated.

An example of an investigation into variability results is if variability for a constituent does not meet the criteria for acceptable reproducibility or reliability because of small constituent concentrations (relative to instrument detection levels). Variability is known to increase as concentration decreases, and the criteria for acceptable variability are not intended to apply to small concentrations.

Contamination bias, rather than instrument background uncertainty (sometimes referred to as “noise”), is considered present in a blank (and potentially a water-quality sample) when a detectable concentration of a constituent is measured from a blank. This corresponds to a concentration exceeding the reporting level of $3s$ (app. 4) for radiochemical constituents and the reporting level for inorganic and organic constituents (tables 3-6). If a constituent is detected in a blank, then the results for that constituent are investigated.

Appendix 7. Inventory of Water-Quality and Water Level Field Equipment

Table 7.1. Inventory of water-quality and water level field equipment.

Type of meter	Model	Manufacturer	Serial number
Multi-parameter	Quanta	Hydrolab	QD01427/QT02017
Multi-parameter	Quanta	Hydrolab	QD02191/QT02018
Multi-parameter	Quanta	Hydrolab	QD02194/QT01467
Multi-parameter	Quanta	Hydrolab	QD03469/QT05153
pH	Orion 3 Star	Thermo Scientific	A16054
Turbidity	2100P	Hach	971200016277
Conductivity	122	Orion	0905040
Digital thermometer	Traceable Memory	Fisher Scientific	61733096
	Data-log 50		
Digital thermometer	Traceable Memory	Fisher Scientific	72068284
	Data-log 50		
Digital thermometer	Traceable Memory	Fisher Scientific	80320036
	Data-log 50		
Digital thermometer	Traceable Memory	Fisher Scientific	101476820
	Data-log 50		
E-tape-1	Water level Indicator – 1,00 0ft	Durham Geo Slope Indicator	38303
E-tape-2	Water level Indicator – 1,000 ft	Durham Geo Slope Indicator	1437380
E-tape-3	Water level Indicator – 1,000 ft	Durham Geo Slope Indicator	36592
E-tape-4	Water level Indicator – 700 ft	Durham Geo Slope Indicator	1437381
E-tape-5	Water level Indicator – 1,250 ft	Durham Geo Slope Indicator	36529
E-tape-6	Water level Indicator – 1,000 ft	Durham Geo Slope Indicator	1637401
Stainless steel tape	Calibration tape – 800 ft	Cooper Tools	Not applicable
Stainless steel tape	Calibration tape – 1,000 ft	Cooper Tools	Not applicable
Stainless steel tape	Calibration tape – 1,200 ft	Cooper Tools	Not applicable

Appendix 8. Auditor's Checklist for Quality Assurance Field Audits

QUALITY-ASSURANCE FIELD AUDITS

AUDITOR'S CHECKLIST

Auditor's name _____

1. Date _____ Sampler's name _____ Site name _____

2. Vehicle:

Was the vehicle clean and well maintained? Yes / No

Was the vehicle well stocked? Yes / No

Were the field computer and printer working properly? Yes / No

3. Site Inspection? Yes / No Details _____

4. Water-level measurement? Yes / No

Electric tape

Depth 1 below MP _____

Recorded on WL trip sheet Tape correction 1 _____

and laptop computer? Yes / No Depth 2 below MP _____

Tape correction 2 _____

MP _____

5. Portable discharge lines rinsed with DI water? Yes / No

6. Generator:

Grounded? Yes / No

Parked downwind from well? Yes / No

7. Time pump started? _____ Discharge measured? Yes / No Q = _____ gpm

Purge time calculated? Yes / No T = _____ min/vol

Time readings stabilized? Yes / No

8. Field safety equipment:

Shovel? Yes / No Site-safety plan? Yes / No

Bucket? Yes / No QA plan? Yes / No

First-aid kit? Yes / No Body-fluids kit? Yes / No

Fire extinguisher? Yes / No Safety vest (if required)? Yes / No

Eye-wash kit? Yes / No Cell phone? Yes / No

Hearing protection? Yes / No Jumper cables and ice scraper? Yes / No

9. Constituents? _____
Number of bottles and designations _____

10. Calibrations:

Specific conductance? Yes / No
pH? Yes / No
DO? Yes / No
Recorded in logbook? Yes / No
Other? Yes / No Specify _____

11. Field Measurements:

Temperature, water? Yes / No Value = _____
Temperature, air? Yes / No Value = _____
Specific conductance? Yes / No Value = _____
pH? Yes / No Value = _____
DO? Yes / No Value = _____
Other (Specify)? Yes / No Value = _____

12. Sample Collection:

Time started _____
Gloves Yes / No
Filter rinsed with DI and sample water? Yes / No
Air purged from filter? Yes / No
Bottles rinsed with sample if appropriate? Yes / No
Order of filling bottles? Correct Incorrect List _____
Number of rinses? List _____

13. Preservation:

Safety equipment?
Eye shielding? Yes / No
Rubber apron? Yes / No
Protective gloves? Yes / No
Correct preservatives added? Yes / No
Was the correct order followed? Yes / No

14. Sample Handling:

Were sample bottles properly sealed? Yes / No
Were sample bottles properly labeled? Yes / No

Were sample bottles properly stored? Yes / No

Was proper security of sample bottles maintained? Yes / No

15. Decontamination:

Were portable discharge lines rinsed with DI water prior to storage? Yes / No

16. Site Clean-up and Security:

Was the well properly secured after sampling? Yes / No

Was the Site properly cleaned prior to departure? Yes / No

17. Paperwork copies?

Requested? Delivered?

Field observation worksheet? Yes / No Yes / No

Analytical service request form? Yes / No Yes / No

Water-level trip sheet? Yes / No Yes / No

SVMobile site visit notes? Yes / No Yes / No

Calibration logbook sheets? Yes / No Yes / No

PCFF field form? Yes / No Yes / No

Other? (Specify _____) Yes / No Yes / No

18. Comments:

Appendix 9. Emails Listing the Decision Process for Calibration of Tapes Decision

On Thu, Aug 2, 2018 at 10:38 AM Bartholomay, Roy <rcbarth@usgs.gov> wrote:

Lets just apply our current calibrations to our recent records. We can do a batch correction later on if we want to incorporate the HIF steel tape calibration correction.

On Thu, Aug 2, 2018 at 10:29 AM, Amy Wehnke <ajwehnke@usgs.gov> wrote:

Thanks Roy.

I agree as long as we document this, as it is a requirement that we send our tapes to HIF and use HIF calibrations. I do not plan to send any other etapes in at this time and HIF is aware of this, although I am requested to. I will continue to send the steel tapes in as required and hesitantly agree we should start applying the HIF steel tape correct to our calibration procedures. Although I did not do so in July as we wanted to keep procedures the same as past years for study reasons. If you would like me to go back and apply the steel tape correction to July, please let me know soon as I would have to correct July and Aug WL's. Are current HIF calibration for the steel tape would be 0-0.05? Just a thought, do we want to start applying the HIF steel tape calibration correction to our etape calibration procedures before HIF works out any other calibration concerns? I have only focused on the etape issues, and not certain that they have the steel tape calibration procedure finalized.

On Thu, Aug 2, 2018 at 9:03 AM Bartholomay, Roy <rcbarth@usgs.gov> wrote:

My thought remains to use our calibrations to our steel tapes as we have done in the past; I could see incorporating the additional step of applying HIF calibration to our steel tape as our 0 point versus saying our steel tape is the true measurement. That is the only change I would consider for our program for now.

On Thu, Aug 2, 2018 at 11:04 AM Amy Wehnke <ajwehnke@usgs.gov> wrote:

Thanks Phil, I do agree.

Brandy as far as your original email, I do agree tapes will have a negative correction because they are not hanging straight in the well. My concern is HIF's method for calibrating etapes with tension for a straight tape does not replicate how the tape hangs in the field down hole. And, I also agree with Phil that HIF calibrations should not be used if there is a significant difference, rather try to improve the calibration procedures.

On Thu, Aug 2, 2018 at 9:34 AM Gardner, Philip <pgardner@usgs.gov> wrote:

Hi Amy-

We perform out field (down-hole) calibrations using a NIST-certified steel tape rather than a HIF-calibrated steel tape. We have various types of e-tapes RST, Waterline, Solinst, WLI, etc. In general, all of the flat tapes with the wires running down either side behave like you see in the examples I sent. And nearly all of our tapes are of that style. (round tapes of different material like WLIs behave differently and I have other reasons for not liking those but that's getting off topic).

I understand that our e-tapes will have negative corrections because they are not hanging straight in the well. And, since this represents actual field conditions, it doesn't seem like we should be using HIF calibrations that are significantly different. The thing that puzzles me is why so many HIF calibrations result in this increasingly negative correction that is of larger magnitude than ours. HIF pulls force on the E-tapes to straighten them. As I understand it they calculate and "in-use" tension that increases as they move down the tape to represent the

increased weight that results from longer sections of tape hanging in a well. Whether this tension is representative enough of field conditions or not, it still seems that they should be straightening the tape compared to how it would hang in a well, which should result in less of a negative correction, right?

On Thu, Aug 2, 2018 at 6:20 AM, Amy Wehnke <ajwehnke@usgs.gov> wrote:

Thanks Phil

There are similarities in our field calibrations compared to HIF and the increasing negative correction is very concerning from 500-1000 ft. What type of etapes are you using? Are you calibrating to a steel tape that was calibrated at HIF? If the difference is that the etapes are not hanging straight in a well, as Brandy stated, then that needs to be considered in the HIF calibration methods or changed from table calibration to hanging or down hole calibration methods. If conditions vary from WSC because of field conditions (well depth, temp, condensation, deviation, casing material, etc) then maybe there is not one standard lab method of calibration, rather standardize field calibration methods. If HIF steel tape calibrations are acceptable (as ours was) maybe USGS protocol should be to calibrate etapes in the field to HIF calibrated steel tape, where the steel tape is for calibration use only.

On Wed, Aug 1, 2018 at 4:15 PM Gardner, Philip <pgardner@usgs.gov> wrote:

Hi Amy-

I'm attaching a pdf showing this same behavior / comparison between HIF calibrations and our own "down-well" field calibrations. You can see the increasing negative correction that is derived from nearly all HIF calibrators the NV e-tapes have undergone (these tapes have been to HIF twice. You can also see the year to year variability in the results of our own calibrations. We've concluded that the actual uncertainty resulting from all things considered (tapes not hanging straight, temperature effects, friction / condensation in the well, etc. etc. etc.) is on the order of +/-0.05 ft for the first few hundred feet. But...we are still puzzling at the increasing cumulative negative correction that results from the HIF calibration.

I understand the HIF protocols are intended to replicate "in-use" weight on the tape but there is clearly something going on that results in HIF corrections not representing field conditions. Note that this figure only shows four wells, but I can show you many more that look the same.

On Wed, Aug 1, 2018 at 3:36 PM, Amy Wehnke <ajwehnke@usgs.gov> wrote:

INL thoughts please...

I am having a hard time with Brandy's thinking on the "straight tape" or the HIF reference is straight and will always read as a shorter distance to water than the field reference tape. There straight tape is never used to measure WL so how can it read a shorter distance. It is for calibration only and when they calibrate the steel tape and the etape they are both straight. So, if we compare an etape to the calibrated steel tape in the field, wouldn't the field correction for the etape be appropriate to use?

On Wed, Aug 1, 2018 at 3:05 PM Brandy Armstrong <barmstrong@usgs.gov> wrote:

Amy I think you missed the point I was trying to make with my theoretical illustration. What causes the calibration correction of the field tape at HIF to be more negative than a calibration in the field is the larger negative difference between the field tape and the reference. The HIF reference tape will always be straight and if it was calibrated against itself the correction would be zero. The well reference tape will always not be completely straight (reading slightly longer distance to water), and if calibrated against the HIF reference tape the correction would be negative. The tape being calibrated will have a different correction dependent on which

reference tape is being used, and that is what causes the HIF calibration to always result in a larger negative correction (because the reference is straight and will always read as a shorter distance to water than the field reference tape) than in the field (where the reference is not straight and will always read at a longer distance to water than the HIF tape). As you said during a field calibration the reference could be affected by frictional forces or get caught up which would cause it to hang less straight and read even longer. The longer the reference tape reads from the true length, the smaller the negative correction would be for the field tape (assuming it was not also hung up) and if the reference tape got caught up and read particularly long, then you might even have a positive correction. This will never happen to the HIF tape since the calibration is performed on a flat on the table. The only way the field reference could then result in a correction that was more negative than the HIF reference correction is if the field reference was somehow stretched. For a tape where there is a positive correction, the HIF reference tape correction would still be less than an in well field reference correction, but on the positive side.

That is frustrating about the weights giving inconclusive results. It looks like in 3 out of 4 wells the large weight resulted in a smaller negative or positive correction when compared to no weight or a small weight. If you are comparing an electric tape with a weight attached to a steel tape without a weight attached, how do you account for the displacement of the water by the weight attached to the electric tape? Or are you also attaching the weights to the steel tape?

On Wed, Aug 1, 2018 at 2:32 PM Amy Wehnke <ajwehnke@usgs.gov> wrote:

Brandy

I agree in theory that "three tapes hanging down a well and one is perfectly straight (I am sure this is impossible) one is just slightly waved, and one is bent, the bent tape is going to have the largest negative correction".

Although the bent tape represents the path the tape takes down hole (friction and deviation), the same path as the steel tape we calibrate with (friction may vary between the tapes due to material). If the etape is hanging or not as straight as the steel tape due to friction, it would have a larger negative correction. The straight tape represents HIF calibration methods which would be a smaller negative correction, not a larger negative. Which is just the opposite of our calibration results.

To add pain to misery, during our last calibration we added two different weights to the etape on wells greater than 500 ft to see how it would affect the calibration. I expected the correction to be a smaller negative, rather the results are sporadic. We also collected air temp and barometric pressure, which I do not expect to have great effect on the calibration.

I have attached etape 1 calibration file for 2017 and 2018 INL calibration with HIF calibration, including the INL weight test and a separate tab showing air temp and barometric pressure.

Knowing the HIF calibration for INL 1000 ft steel tape was good with a range of 0.00 to - 0.05 for a 1000 ft tape, makes me believe calibrating our etapes to the HIF calibrated steel tape in the field is the best method of calibration as it replicates the field condition they are used.

I would be interested in anyone else's take on this.....

On Wed, Aug 1, 2018 at 1:08 PM, Sheets, Rodney <rasheets@usgs.gov> wrote:

See Idaho's in-well tape calibration results. If you have any input, I'm sure Amy (and I) would like to hear it. Doesn't really look like your in-well deep tape calibrations much.

On Tue, Jul 31, 2018 at 10:12 AM Brandy Armstrong <barmstrong@usgs.gov> wrote:

I was working on my presentation for RWDTC and had a thought. If you have three tapes hanging down a well and one is perfectly straight (I am sure this is impossible) one is just

slightly waved and one is bent, the bent tape is going to have the largest negative correction when compared with the perfectly straight tape. So if the HIF tape table NIST reference tape represents the perfectly straight tape, it makes sense that the negative corrections on a bent tape would be larger at the HIF than they would be down a well even when compared with a very straight tape, since when hanging down a well it could never be perfectly straight like the tape on the HIF calibration table. I made a little illustration, exaggerated for the sake of making it easy to see (left panel represents HIF, middle represents down well calibration).

Along the same vein, if you were using a correction for a steel tape that had been calibrated at 10 lbs tension, and then using that steel tape as the reference for an in well calibration of the electric tape, where the steel tape is now being used at in-use tension, then the steel tape is likely to have a different correction (slightly less/more negative) in the well than it did on the table, and contribute to the difference between a calibration of an electric tape at HIF compared with a calibration of an electric tape in the field.

I think this could explain why the HIF calibration shows a LARGER negative correction than the field calibration, and it is particularly noticeable on this tape because of the poor quality in the spacing on the markings of the tape. We have yet to run across another one like it.

I was thinking about including this in my talk at RWDTC. Please let me know if you think this is a plausible explanation for what happened with regards to this tape.

On Thu, Oct 19, 2017 at 10:52 AM Wehnke, Amy <ajwehnke@usgs.gov> wrote:

Brandy, I do not have a problem with you holding on to the tapes. Will HIF be checking just the etape or the steel tape also? I would be curious how the calibrations with bearings differ.

Yes, our calibration is showing a greater stretch at deeper depths compared to HIF. Which would not be temperature as ours temps are cooler down hole (compared to HIF temp), ours should be contracting due to temp, not stretching more.

As far as the twisting that I was seeing on our tapes after HIF calibration, it was mainly the first 30 ft of the tape and mostly near the probe (more concerned about the tension between probe and tape when stretched).

The etape and calibration steel tape take the same path down hole, regardless of deviation or well construction. Our steel tape calibration (HIF) was -.05 at 1000 ft and our etape differs 1.12 from down hole calibration and HIF calibration. Have had similar differences with field calibration and HIF calibration on other 1000 ft etapes?

Please keep me posted.

On Wed, Oct 18, 2017 at 1:06 PM, Armstrong, Brandy <barmstrong@usgs.gov> wrote:

They did recalibrate your 1000 ft tape and afterwards we decided it would be good to do a repeatability study on the electric tapes (the previous study was done on steel tapes) using some of the sample tapes we had in the QC room. So, we were holding onto it while we did the study, but it is taking longer than we thought. We have finished the two calibrations on your etape and can send it back if you need it.

Attached are the two calibrations for your etape copied into the original excel sheet that you sent me. Our two calibrations agree fairly well, but there is a difference that builds up the further we get down the tape. I had originally thought maybe this was stretching (especially since you had made the comment about the twisting and the tapes might be stretching at the data conference), but I was thinking about it backwards. It is actually showing that the second measurement was shorter, not longer. We think this has to do with the friction on the table and Blu is installing some bearings to help reduce the friction on the table. If you want to leave the

tape with us, we can calibrate it again after the bearings are put in. If you need it back, just let me know and I will have them send it back to you.

Let me know if you have additional questions.

On Tue, Sep 26, 2017 at 8:38 AM, Armstrong, Brandy <barmstrong@usgs.gov> wrote:

We will calibrate the electric tape one more time. Right now, the temperatures have been in the upper 80's and the lab is not temperature controlled, so it is likely close to that in the lab.

On Mon, Sep 25, 2017 at 4:03 PM, Wehnke, Amy <ajwehnke@usgs.gov> wrote:

Brandy

Attached are the fielded and HIF calibration graph and calibration files. I have also included our steel tape and etape measurement used to calculate the calibration for etape-1.

The trend to the HIF calibration is a consistent trend, although still not following the trend to the infield calibration. Assuming HIF will re-calibrate a second time, as we discussed, please keep me posted on the results. In the meantime I am trying to make sense of the differences.

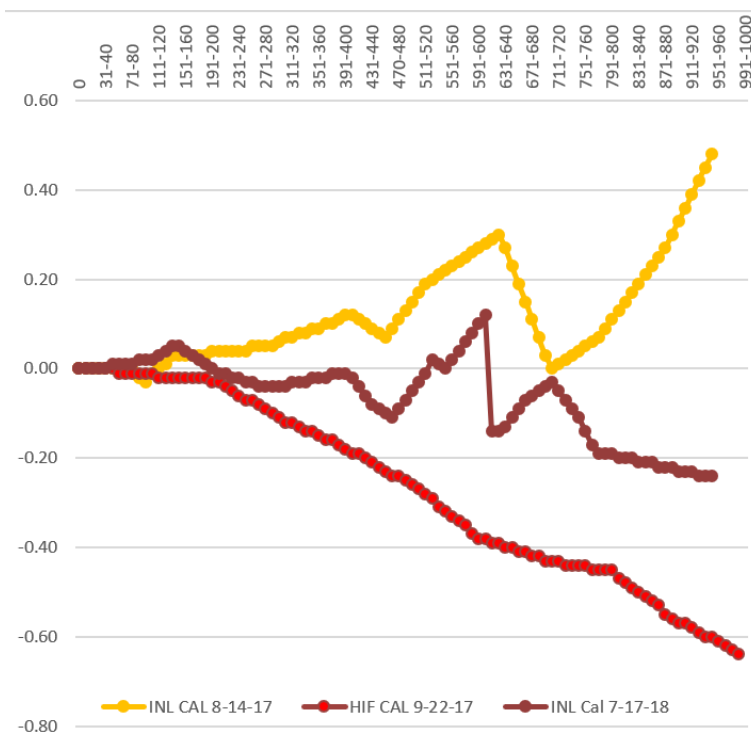
On a lighter note, I am pleased with the steel tape calibration.

If I remember correctly, calibrations are done with no temperature variable? What is the average temp condition during calibration?

On Mon, Sep 25, 2017 at 8:35 AM, Armstrong, Brandy <barmstrong@usgs.gov> wrote:

Amy and Rod,

Please find attached a pdf of the calibration tables for the two tapes, one electric and one steel. Although the steel taps is spliced at 500 ft and the markings start over at 1ft, in order to have the tables work correctly they entered the actual length of the tape (for instance 501 ft instead of 1 ft) in order to make the software that calculates the calibration table work correctly. Unlike the previous tape, these tapes appear to be pretty consistent with the error increasing over the length of the tape. Please take a look and compare to your in-well calibrations. We are holding the tapes in the lab.



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